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Navigating Adversity: Unravelling the Gendered Effects of Climate Shocks and Migration

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Abstract

This thesis investigates the impacts of covariate shocks, like natural disasters, and idiosyncratic shocks, like migration, on household well-being in Bangladesh and Uganda. Although flood is one of the most frequently occurring climate disasters and its frequency is projected to further increase, flood effects have received comparably little attention. Furthermore, existing literature mostly focuses on the migration of men or parents who leave their wife and children behind, neglecting the different household dynamics caused by the migration of young adults to their parents and siblings. Exploiting panel survey and satellite data, this thesis contributes to filling these gaps by analyzing the consequences of floods and migration on households and individuals, accounting for gender-specific effects. The first chapter reveals that floods have immediate adverse impacts on household food security and individual nutrition in Bangladesh, with female-headed households and female landowners experiencing more severe short-term impacts but also demonstrating significant recovery capacities. The second chapter finds that flood exposure in Karamoja, Uganda, is associated with increased support for violence, highlighting the complex relationship between weather shocks and conflict risk. The third chapter shows that the migration of young household members in Bangladesh affects the well-being of those left behind, with sons' migration improving mothers' and brothers' nutritional status but reducing boys' school attendance. This research underscores the resilience of households facing migration and weather shocks and emphasizes the need for gender-sensitive policies. Effective interventions should support female-headed households in flood-prone areas and address the educational disruptions caused by migration. By considering gender dynamics, policymakers can better enhance household resilience and well-being in the Global South.

Keywords: Floods; Migration; Wellbeing; Gender.
JEL Classification: Q54; O15; I31; J16.

Alla mia nonna Miria.

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Introduction

Shocks can come in many forms, and can be classified according to their scale of impact. Covariate shocks, such as natural disasters, affect entire communities simultaneously, while idiosyncratic shocks, like individual migration, impact specific households. Understanding these distinctions is essential for analyzing their effects on development (Dercon and Christiaensen, 2011; Mukherjee et al.; Dercon, 2002). Covariate and idiosyncratic shocks, significantly affect households, especially in low-developed areas (Kaczan and Orgill-Meyer, 2020; Barua and Banerjee, 2020). These shocks, such as floods and migration, can affect consumption patterns (Endalew and Sen, 2020; Skoufias and Vinha, 2012), food insecurity (Niles and Salerno, 2018), conflict risk (Ghimire and Ferreira, 2016) and resource allocation (Chen, 2006; Antman, 2013). These potential changes, vary based on the different nature these shocks and the context analysed. Furthermore, in the Global South these effects can be further exacerbated for women. This is due to the fact that women are often disadvantaged compared to men, making them particularly vulnerable to adverse shocks (Malapit et al., 2015; Ehsan and Akter, 2020). This thesis aims at investigating through empirical analysis, the consequences of these two types of shocks on household and individuals, as well as the mechanisms that drive these effects.

Flood is one of the most frequently occurring climate-related disasters (CRED, 2023). The frequency of natural hazards is projected to further increase in the coming decades due to climate change (IPCC, 2022). While slow-onset events accumulate over a longer period and often affect large areas, rapid-onset events like flash floods from heavy rainfall can occur suddenly and unexpectedly and in areas that are far away from rivers. Insights from research on slow-onset events may not be directly applicable to floods due to their different nature (Koubi, 2017; Ward et al., 2020). Yet, flood effects have received comparably little attention (Famiglietti et al., 2021). Additionally, rural households, who rely on agriculture to sustain their livelihoods, feel flood impacts more strongly (A. Trinh, 2019; Cohn et al., 2017), and differences are seen across regions and individuals (Zhou et al., 2022).

Weather shocks, like floods, have a significant impact on food and nutrition security, leading to food scarcity, reduced dietary diversity, and increased food insecurity (Reed et al., 2022; ACHOJA, 2019; Week and Wizor, 2020; F. Centa, 2009; Joshua et al., 2021; Sam et al., 2021; Gabrysch et al., 2018; Atubiga and Donkor, 2022). These effects are particularly pronounced for farmers, who rely on rain-fed agriculture (Atubiga and Donkor, 2022), households with female heads (ACHOJA, 2019; Joshua et al., 2021; Sam et al., 2021; Ajaero, 2017; Mwesigye, 2021) and female land managers (Asfaw and Maggio, 2018). The destruction of crops, homes and livelihoods caused by flooding events, exacerbates the challenges posed by pre-existing adverse climate conditions (Joshua et al., 2021; Sam et al., 2021).

Concerns about implications of natural hazards, for conflict risk are growing and research on this topic has rapidly expanded over the past decade. Overall, findings on general links are mixed, and research increasingly points to a conditional relationship where climate-related hazards increase conflict risk in some contexts but not in others (Koubi, 2019). Floods can fuel existing armed conflicts and raise the risk of civil conflict, particularly in developing countries (Ghimire et al., 2015). This exacerbation is highlighted by the role floods play in instigating urban social disorder and contributing to an increased risk of conflict (Castells-Quintana and McDermott, 2019; Ghimire et al., 2015).

Migration, on the other hand, is a complex phenomenon influenced by various economic, social, environmental, and policy factors. This can manifest as either individual migration of family members or the relocation of entire households. In the Global South[1], economic and education opportunities often serve as primary drivers, prompting individuals to migrate in search of better employment and life prospects (DESA, 2020; IOM, 2021). The migration of individual household members, rather than entire households relocating together, influences the lives of both migrants and the family members they leave behind as children and parents (Saleemi, 2023). The departure of family members reshapes household dynamics, impacting labor costs and internal structures (Giannelli and Mangiavacchi, 2010; Zhunusova and Herrmann, 2018), with implications stretching to food consumption, education, and resource allocation (Zhang et al., 2015).

Despite the strides made over the past century, gender disparities persist across various facets of women's daily life. Women experience greater disadvantages compared to men in terms of consumption, education, health, labor market outcomes, and social mobility (Bank, 2013). Additionally, they are constrained by gender norms that limit their roles and opportunities within society to those of daughters, wives, and mothers (Asfaw and Maggio, 2018), unequally confining them to the domestic sphere (Anxo et al., 2011; Ferrant et al., 2014). In these contexts, gender factors significantly shape the consequences of weather shocks and the migration

[1]The "Global South" is a term used to describe regions of Latin America, Asia, Africa, and Oceania that are typically characterized by lower levels of industrialization, economic development, and human development compared to the "Global North" (North America, Western Europe, and developed parts of East Asia). From an economic perspective, Global South countries often exhibit lower GDP per capita, higher levels of poverty, and greater income inequality compared to their Global North counterparts (Source: UNCTAD (2023). UNCTADstat. Available at https://unctadstat.unctad.org)

patterns. Generally, cultural norms and socio-economic factors exacerbate women' vulnerability to climate change and climate-induced shocks (De Pinto et al., 2020). This, in turn, threatens women's abilities and opportunities to achieve a greater level of food security and overall well-being (Eastin, 2018). Furthermore, these factors also influence the different way in which women and men experience migration. This withstands, both when they migrate and when they are left behind, depending on their role in the household and the remittance flow (Rahman and Sheema, 2021; Islam and Sharma, 2021; Islam et al., 2019; Saleemi, 2023).

This thesis examines different dimensions of the consequences of covariate and idiosyncratic shocks, in low-income countries. The aim is to unfold the nuanced consequences for households and individuals, to provide valuable contribution for evidence-based policy making. Starting from the weather events, this study first analyses the gendered impact of exogenous flood shocks on household food security and individual nutrition, in Bangladesh. Then, it studies the consequences of floods on, and the pathways towards, the support for violence in the Karamoja region of Uganda. Lastly, it shifts focus to idiosyncratic shocks, addressing how the migration of young Bangladeshi members affects the left-behind's nutrition, education and time allocation, under gendered perspective. Through the adoption of panel and satellite data, this thesis answers different research questions that lie at the intersection of applied microeconomics, development economics, and feminist economics in two different settings: Bangladesh, and Uganda.

These countries provide interesting settings for studying these topics, for different reasons. Bangladesh provides an excellent case study due to its predominantly agricultural economy, which makes it highly climate-dependent and vulnerable to weather shocks. Additionally, its low-lying geography and the confluence of major rivers make it highly susceptible to flooding, with severe gender-differentiated impacts on health, food security, and access to resources (Eckstein et al., 2021; De Pinto et al., 2020). Moreover, food and nutrition security is a pressing issue, with 33% of the population experiencing moderate-to-severe food insecurity (FAO et al., 2021). On top of these reasons, gender disparities are significant in Bangladesh. Many women in lack control over income and resources, face mobility restrictions, and have limited decision-making power within households (Jayachandran, 2021; Malapit et al., 2019; Schuler and Rottach, 2010; Sraboni et al., 2014). Consequently, women are more adversely impacted by floods compared to men in Bangladesh (Brouwer et al., 2007). The country also faces high secondary school dropout rates, especially at the secondary level (Jabbar, 2022; Sarker et al., 2019). Additionally, Bangladesh ranks among the top countries of origin for international migrants, and rural-urban internal migration is a common occurrence. These migration patterns vary by gender (IOM, 2021; Rahman et al., 2021).

The Karamoja region, in north-eastern Uganda, presents a compelling case study due to its history of armed conflict, resource-related disputes, and vulnerability to climate change (Koubi, 2019; Buhaug et al., 2021). With a population of 1.2 million, primarily engaged in smallholder agriculture, and around 60% living in absolute poverty, it stands as Uganda's least developed region (Stites and Howe, 2019; of Statistics, 2017). The area's agroecological zones, traditional livelihood practices, and frequent internal seasonal mobility of pastoralist households, underscore its susceptibility to climate-related risks (Stites and Howe, 2019). Persistent violence, including communal conflicts and clashes with government forces, adds complexity to the region's challenges (Oketch and Otwii, 2021; Abrahams, 2020). Additionally, Karamoja faces variable climate patterns, with severe floods in 2018 causing crop damage, disrupting essential services and heightening health risks (Ssekandi, 2018; ActionAid, 2018). This makes Karamoja a crucial case for studying the intersection of climate vulnerability, armed conflict, and their impact on livelihoods and human security.

The first chapter, "Analysing well-being and gender: The impact of floods on food and nutrition security in Bangladesh", analyses the gender-differentiated impacts of floods on household food security and individual nutrition in rural Bangladesh. Previous studies have largely examined the impacts of weather shocks and food security, often neglecting the intersection of gender with these phenomena. There is a notable gap in understanding the gender-differentiated impacts of floods on food and nutrition security in rural households. Existing research typically focuses on short-term effects and lacks comprehensive analysis over extended periods using detailed datasets (Siddiqi, 2014; Buhaug and von Uexkull, 2021). This chapter addresses gaps in the existing literature by combining two separate strands in a common framework: the gender-differentiated household outcomes and the impact of weather shocks on household well-being. By uniquely combining household survey data with satellite flood data, it accurately measures flood exposure and provides a robust framework for analyzing the impacts of climatic events. The study offers a novel examination of both the immediate and long-term effects of floods at the household and individual level. It also distinguishes itself by considering all rounds of Bangladesh Integrated Household Survey (BIHS) - which most studies have exploited only the first two rounds – allowing for a more accurate, reliable and comprehensive analysis. Additionally it emphasizes the role of gender in shaping food security outcomes, particularly in the context of female-headed households and female land ownership (Flatø et al., 2017; Sekabira and Nalunga, 2020; Asfaw and Maggio, 2018). The aim and relevance of this study lies in its comprehensive approach to understanding how gender dynamics influence the recovery of rural households affected by floods over time. This is particularly important for designing gender-sensitive interventions and policies that address the vulnerabilities and strengths of different household members, especially in regions prone to weather shocks like Bangladesh (IPCC, 2021).

The second chapter, co-authored with Nina von Uexkull and Marco d'Errico, "Climate, flood and attitudes toward violence: micro-level evidence from Karamoja, Uganda"[2], investigates how flood exposure affects the support for violence in the Karamoja region of Uganda. Overall, findings on the general links between natural hazards and conflict risk reveals mixed results (Koubi, 2019). Global and regional studies have identified broad patterns, but the specific pathways between flood and violent outcomes at individual and household levels remain poorly understood (Mach et al., 2020; von Uexkull and Buhaug, 2021). This study aims to address these gaps, by examining attitudes toward violence and changes in socio-economic conditions at the individual level following a destructive flood. The focal event in our study is a particularly severe flood event that occurred in 2018, affecting over 180,000 Ugandans and resulting in an estimated crop loss of 60 to 80% (Ssekandi, 2018; NET, 2018). Moreover, the extensive flooding impeded access to essential services, leading to additional health and malnutrition challenges, along with direct casualties (ActionAid, 2018). In this region, the local population is predominantly pastoralists, and the use of violence is primarily associated with males, particularly in the context of cattle-raids (Stites and Howe, 2019). Therefore, our analysis focuses on understanding the relationship between flood exposure and support for violence, without considering gender dynamics.

The third chapter, co-authored with Marrit van den Berg "What happens to the wellbeing of the left-behind when young adults migrate? A Gendered analysis" analyses the impact of sons and daughters migration on the well-being of parents and siblings left behind in rural Bangladeshi households. The literature on individual migration and those left-behind, has focused on the experiences of children whose parents migrate leaving them behind (Antman, 2013) and on males or husbands who leave their families and wives behind (Rahman and Sheema, 2021; Islam and Sharma, 2021; Islam et al., 2019; Antman, 2013). However, younger members of the household, such as adult sons and daughters, may migrate too. Notably, shifts in household dynamics resulting from the migration of younger family members such as adult children may respectively influence the well-being of parents and siblings who do not migrate (Antman, 2010, 2014, 2013, 2012). The implications for those left behind by adult sons and daughters

[2]This chapter was published as: von Uexkull, N., Loy, A. & d'Errico, M. *Climate, flood, and attitudes toward violence: micro-level evidence from Karamoja, Uganda*. Reg Environ Change 23, 57 (2023). https://doi.org/10.1007/s10113-023-02054-x

can be different from those left-behind by parents and spouses, depending on the migrant's gender and position in the household. This chapter aims at filling these gaps by exploring how the migration of sons and daughters affects the nutritional status, schooling, and time allocation of the left behind.

Given the different nature of the research questions, this thesis adopts different datasets and empirical methodologies. The first chapter examines household food security and individual nutrition responses following devastating floods in Bangladesh. In this analysis, I utilize three rounds of the Bangladesh Integrated Household Survey (BIHS) panel dataset, collected in 2011/2012, 2015, and 2018/2019. The BIHS datasets are well-suited for studying intra-household dynamics, as they provide detailed information on various topics, including food consumption, anthropometric measures, agricultural production, technology use, livelihood and land ownership. To measure the severity of the floods, our treatment variable, I use the NASA Flooding Map, which consists of 250-meter resolution images that define flooded areas as water observations falling outside normal water levels. I then determine the intensity of exposure to the flood for each sampled household by calculating the share of pixels identified as "flooded" within a 5-kilometer radius of each household (Gröger and Zylberberg, 2016). This analysis covers the floods that occurred during the monsoon seasons of 2013, 2014, 2017, and 2018.

The second chapter examines survey responses following the 2018 flood in Karamoja, leveraging novel sub-nationally representative panel household-survey data collected in 2016 and 2019 by UN FAO. This unique dataset enables the tracking of households and individuals before and after a devastating flood, facilitating the study of variations in attitudes towards violence. Our investigation is situated in the conflict-affected Karamoja region of Uganda, characterized by structural features that previous research suggests may exacerbate conflict risk following climate-related hazards. The sample comprises 1965 households interviewed in both survey rounds, forming a balanced panel. To gauge flood exposure, we rely on self-reported data concerning flood exposure within the preceding 12 months. Employing various identification strategies, we aim to discern causal effects and maximize the utility of the comprehensive dataset. Initially, we establish the direct association between flood exposure and support for violence in the cross-section. Subsequently, we examine flood impacts on material and subjective conditions using difference-in-differences (DID) estimation based on a household-level panel. Lastly, we conduct a causal mediation analysis to explore specific pathways underlying the observed effects.

The third chapter studies the responses to son and daughter migration concerning the well-being of parents and siblings left behind in rural Bangladeshi households. Exploiting panel data from the Bangladesh Integrated Household Survey (BIHS) from 2015 and 2018-19, we retrieve valuable information on migrated household members and those left-behind. This enables us to examine the nuanced effects of these young members' migration, through gender lens. The migrant households are defined as household that have at least one person that was a member of the household during 2015 survey round but has been living away for six months or more within the country but not in the same Upazilla (subdistrict) or abroad. The non-migrant households are defined as households that never had a migrant member in all the past survey rounds (around 12 years). Our sample is composed by 641 migrant households (of which 474 and 324 households have at least one migrant son and daughter, respectively) and 2657 non-migrant households. By employing an instrumental variable approach, we address the endogeneity of migration and provide a robust Two-Stage Least Squared analysis of these complex relationships.

Each chapter provides interesting and important results for gender inequalities in low- and middle-income countries. The first chapter indicates that floods occurring between 2013 and 2018 had an immediate adverse impact on household food security and individual nutrition. However, households exposed to multiple shocks demonstrated a capacity to recover over time, often facilitated by factors as cash assistance, income diversification and the advantages of flood-irrigated fertile lands (Gröger and Zylberberg, 2016; NASA, 2022). Notably, female adults, female-headed households and those with female landowners experienced more severe short-term negative effects. Despite all adversities, these households also exhibited significant capacities to bounce back, indicating a nuanced interplay between vulnerability and recovery. The second chapter provides evidence that flood exposure is associated with higher support for the use of violence in Karamoja. This is an important result given the mixed findings on the relationship between floods and conflict in the limited existing research, which often points to conditional relationships (Ide et al., 2021; Petrova, 2021). Additionally, the chapter explores potential pathways through which the observed flood effect may have materialized. The analysis reveals that flood exposure is linked to a modest increase in the use of coping strategies, as well as losses in livestock and perceived political capital. Surprisingly, the mediation analysis did not support these factors as mediating the direct flood effect on attitudes towards violence. Changes in these variables did not align with expectations regarding their correlation with support for violence. Micro-level causal mechanisms between climate and conflict thus deserve further exploration in future research.

The third chapter shows that the migration of young household members has multifaceted effects on those left behind. Specifically, the migration of sons affects the nutrition, education, and daily activities of their parents and siblings. Sons' migration leads to improved nutritional status for their mothers and brothers, likely facilitated by remittances often directed towards food consumption (Nath and Mamun, 2010; Kumar et al., 2018). However, a downside of sons' migration is decreased secondary school attendance for boys left behind, possibly due to their increased involvement in household duties previously handled by the migrant son (Jabbar, 2022). This phenomenon aligns with existing research indicating that siblings of migrants, particularly older ones, may be more inclined to skip school to assist with household chores, especially in rural settings where agriculture is a primary source of livelihood (Admassie, 2003). Furthermore, the impact extends beyond nutritional and educational aspects to the daily activities of left-behind mothers. Sons' migration causes a notable shift in mothers' time allocation, characterized by reduced involvement in domestic work and increased engagement in productive activities and leisure pursuits. In contrast, the migration of daughters has a different effect on mothers, leading to a reduction in leisure time as mothers take on tasks previously undertaken by their migrated daughters. This disparity underscores prevailing gender roles within households, with women often bearing the brunt of domestic responsibilities, particularly in contexts where female members migrate (Bandiyono, 2016).

This thesis addresses the impact of covariate and idiosyncratic shocks. Shocks such as floods and individual migration, while distinct in nature, both significantly affect households and communities in the Global South. Floods cause immediate damage requiring emergency responses, whereas migration alters household economic and internal structures. The three most important takeaway messages from this work are the following. Firstly, the results suggest that households facing adverse shocks can exhibit significant resilience and adaptability, particularly when supported by remittance inflows and social safety nets. The findings emphasize the importance of considering gender dynamics in policy formulation. Support systems and interventions should be tailored to address the specific vulnerabilities and strengths of different household members. For instance, cash assistance and income diversification strategies should be designed to particularly support female-headed households and female landowners in flood-prone areas. Similarly, policies to support the families of migrants should take into account the increased domestic burdens on mothers and the educational disruptions for boys left behind, ensuring that remittances can be used effectively to support both nutritional and educational outcomes.

Secondly, the results underscore the importance of understanding the diverse impacts of floods in different contexts. This work highlights gaps in understanding the linkages between weather shocks, household wellbeing, and socio-political outcomes. Additionally, the estimated economic impacts of natural hazards have limited explanatory power for the flood-violence relationship based on the available data. This points out the context-specific nature of pathways and emphasizes the limited explanatory power of analyses focusing solely on the economic impacts of natural hazards (Siddiqi, 2014; Buhaug and von Uexkull, 2021). Based on our findings, violence could be further spurred by flooding and related weather-hazards, but focusing on dampening economic effects of hazards alone may not be effective for preventing this violence increase. Future research should delve deeper into the micro-level mechanisms through which floods impact households, exploring both immediate and long-term effects. This comprehensive approach can inform more effective policy interventions that not only support recovery but also build long-term resilience and social cohesion.

Lastly, policymakers need to consider the gendered repercussions of idiosyncratic shocks i.e. young adults' migration, to better support the well-being of families left-behind. The positive impact of remittances from sons on nutritional outcomes underscores the importance of income flows in enhancing household food security. The negative effect of sons' migration on boys' school attendance suggests a trade-off between household labor and education, highlighting the need for interventions to mitigate these educational disruptions. Additionally, understanding the shift in household dynamics, where sons' migration reduces the domestic burden on mothers while daughters' migration increases it, can help design more effective support mechanisms that address these gender-specific impacts. This study emphasizes the necessity of gender-sensitive policies in addressing the complex socio-economic effects of migration on left-behind family members in rural Bangladesh. In conclusion, this thesis highlights the complex interplay between weather shocks, gender, and household dynamics. It underscores the need for gender-sensitive approaches to address the socio-economic effects of covariate and idiosyncratic shocks on households. Interventions should target the specific vulnerabilities and strengths of different household members, ensuring that recovery efforts and migration policies consider the distinct impacts on women and men. By acknowledging and addressing these gendered effects, policymakers can enhance the resilience and well-being of all household members in the Global South.

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Chapter 1

Analysing well-being and gender: The impact of floods on food and nutrition security in Bangladesh

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Abstract

The consequences of weather shocks are not gender neutral, differentially impacting women through factors such as social and gender norms, limited resource access and decision-making power. The purpose of this paper is to investigate how gender-related factors impact the food and nutrition security of rural households, in a flood-prone gender-differentiated country such as Bangladesh. I build a household-panel dataset (years 2011-2019), matched with flood satellite maps provided by NASA. The novelty of this paper is twofold: I analyse in a common framework the gender-mediated impact of weather shocks on household members' food and nutrition security, and use all the Bangladesh Integrated Household Survey (BIHS) survey rounds. The results show an immediate detrimental effect of floods on household food security and adult nutrition. However, rural households unveil the ability to recover from these weather shocks, especially when they are flooded multiple times. These results are supported by the gender heterogeneity analysis, and indicate significant differences: female-headed households and female adults are more negatively impacted by floods in terms of their dietary diversity and nutrition; and female ownership of land (full or partial) exacerbates the negative effects of floods also on food consumption. Moreover, the alleged recovering mechanism seems to be channeled through females (heads, members and land-owners), suggesting that although they are vulnerable to these shocks, they are also those who are better able to recover and bounce back in the long-run. The paper concludes discussing policy implications, providing insights that could inform the design of targeted gender-sensitive interventions in the wake of weather shocks.

JEL Classification: Q54; J16; Q18; I31

Keywords: weather shocks; gender; food nutrition security; Bangladesh.

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1.1 Introduction

Climate change is projected to increase temperatures, rainfalls and extreme weather events (IPCC, 2021, 2012). Extreme weather events disproportionately affect the most vulnerable, agriculture-dependent populations, whose poverty, inequality and disadvantages are going to further increase (IPCC, 2018; Radosavljevic et al., 2021). This, in turn, can result in lowered food security, nutrition, wellbeing (Knippenberg et al., 2019) and growth (Bhorat and Naidoo, 2019; Cornia and Martorano, 2019). Weather shocks have detrimental effects on different aspects of food security: food production and availability, food distribution and access, food consumption and food system stability. This happens because climate change creates scarcity of food supply as production is damaged or destroyed, hence food access and consumption decrease (Tanny and Rahman, 2017). The level and variability of rainfalls is identified as an important determinant of household food insecurity (Demeke et al., 2011; Maccini and Yang, 2009). These adverse effects come at a time where globally over 2 billion people do not have regular access to safe, nutritious and sufficient food (FAO, 2021).

Moreover, women, especially in the Global South, often bear a greater burden during extreme weather events due to factors such as social and gender norms, limiting their access to resources. These vulnerabilities are exacerbated in the aftermath of weather shocks (Owusu et al., 2019; De Pinto et al., 2020; Naz and Saqib, 2021). Rural communities, in particular, exhibit gender-specific vulnerabilities to weather extremes due to differential access to information, services, technologies, trainings and financial resources (Paris and Rola-Rubzen, 2018). The already unequal access to resources, along with the lower access to food, water, and services caused by weather shocks, influences the distinct ways in which women and men are respond to adverse weather shocks (Paris and Rola-Rubzen, 2018). The effects of weather shocks are not gender neutral, disproportionately impacting women more than men (Chanana-Nag and Aggarwal, 2018), threatening women's abilities and opportunities to achieve a greater level of well-being (Eastin, 2018). For example, more severe consequences are observed for female-headed households (Flatø et al., 2017) and those where women are solely responsible for land management (Asfaw and Maggio, 2018), leading to reductions in total consumption, food intake, and daily caloric intake and nutrition.

There is a notable gap in understanding the gender-differentiated impacts of floods on food and nutrition security in rural households. Existing research typically focuses on short-term effects either on household food security or on nutrition, and lacks gender-comprehensive analysis[1]

[1] A "gender-comprehensive analysis" refers to an approach that incorporates a thorough consideration of gender-

over extended periods (Siddiqi, 2014; Buhaug and von Uexkull, 2021). This paper contributes to fill these gaps by examining the immediate and long-term effects of floods on household food security and individual nutrition, in rural Bangladesh. Additionally, it emphasizes the role of gender in shaping food security outcomes, particularly in the context of female-headed households and female land ownership. This work contributes to two strands of literature: on the gender-differentiated household outcomes (Mehar et al., 2016; Hossain et al., 2021) and on the impact of weather shocks on household well-being (Ansah et al., 2021; d'Errico et al., 2019; Demeke et al., 2011). I aim to combine the aforementioned literature strands answer the following research questions *"What is the effect of flood intensity on household's food security and individuals' nutrition?"*, *"How do gender characteristics shape these effects?"* and *"What are the underlying mechanisms driving these effects?"*.

I use the Bangladesh Integrated Household Survey (BIHS), a panel datasets of rural households, composed by three rounds (2011-12, 2015, 2018-19). The second contribution of this work, from the empirical viewpoint, is that is considers all rounds of the BIHS - whereas most studies have only exploited the first two rounds (Islam, 2018; Islam et al., 2016) - allowing for a more accurate, reliable, and comprehensive analysis. By uniquely combining household survey data with satellite flood data (NASA, 2022), it accurately measures flood exposure and provides a robust framework for analyzing the gendered-impacts of climatic events.

Bangladesh is an excellent case study this topic. According to the 2021 Global Climate Risk Index, Bangladesh is one of the most vulnerable countries to climate change and climate variability (Eckstein et al., 2021). Being located in a predominantly low-lying region at the intersections of the Ganga, Meghna, and Brahmaputra rivers, Bangladesh is one of the most vulnerable countries to flooding due to a combination of storm surge, sea level rise, and higher precipitation (De Pinto et al., 2020; Karim and Mimura, 2008). Between 1999 and 2018, Bangladesh experienced 191 climate-related extreme events (Chen et al., 2021) with serious impacts on the lives of the most vulnerable people (Parvin et al., 2016). Indeed, weather shocks severely affect several sectors in Bangladesh, including agriculture, water resources, and health (Garai, 2014; Babalola et al., 2018). Given that Bangladesh is primarily an agricultural country relying on rain-fed agriculture [2], weather shocks are anticipated to profoundly impact people's livelihoods. These shocks result in reduced rice production across all three of the country's growing seasons, significantly affecting fisheries, and diminishing the nutritional value of food

related dynamics in the analysis, aiming to address and understand the differential impacts, roles, and needs of different genders within specific contexts (World Bank, 2020).

[2]In Bangladesh, 76% of population lives in rural areas, and 90% is directly involved in agriculture. Agriculture absorbs about 44% of the workforce (Chen et al., 2021).

products (De Pinto et al., 2020). As a result, weather adverse shocks are expected to exacerbate Bangladesh's food and nutrition insecurity. Moreover, notwithstanding recent improvements, food insecurity and malnutrition remain serious problems in Bangladesh (Dev and Kabir, 2020; De Pinto et al., 2020). According to FAO, a third of the Bangladeshi population still suffers moderate-to-severe food insecurity (FAO, 2021).

Furthermore, in Bangladesh women often face significant disadvantages compared to men due to deeply rooted gender norms and societal expectations. These norms traditionally emphasize the roles of women as caregivers and homemakers, limiting their opportunities for education, employment, and economic independence (Hossain and Tisdell, 2005). Women frequently have less access to resources such as education, healthcare, and financial services, which exacerbates gender disparities (Mahmud and Tasneem, 2014). Social and cultural practices, including early marriage, further constrain women's autonomy and opportunities (Naved and Persson, 2005). Nonetheless, in Bangladesh, women own significantly less land compared to men and face substantial barriers to property rights. Legal and social restrictions prevent many women from owning or inheriting land, water rights, or livestock, which limits their economic independence and decision-making power regarding family assets (Sourav, 2015; A. Karim, 2012). Studies show that only about 10.10% of land is owned by women in Bangladesh, despite women making up nearly half of the population (Kieran et al., 2015). These disparities are rooted in patriarchal norms and legal frameworks that favor male ownership, significantly affecting women's economic well-being and social status (Mahmud et al., 2021) and limiting their access to resources and recovery mechanisms (Hossain, 2021). Social norms often restrict women's mobility, preventing them from seeking safety and assistance during emergencies (USAID, 2018). The increased burden of household and care-giving duties during and after climate-related events further exacerbates their vulnerability. Higher fatality rates among women during cyclones and floods highlight the severe impact of these disasters on their lives (Krupnik, 2018). Efforts are being made to address these issues, but significant challenges remain in achieving gender equality and enhancing women's resilience to weather shocks in Bangladesh.

The results show that the floods occurring between 2013 and 2018 in Bangladesh have negatively impacted the food and nutrition security of rural households. However, the immediate disruptive effect of floods seems to be counterbalanced by the rural households' ability to recover over time. Moreover, the results suggest gender differentials in terms of household headship and land ownership. Female-headed households are more negatively impacted by floods compared to their male counterparts in the short run, particularly in terms of dietary diversity and nutrition. Full or partial ownership of land by females exacerbates the immediate negative effects of floods on food consumption, diversity, and nutrition. However, the alleged recovery mechanisms seems to be channeled through females. Female-led rural households, despite being more disadvantaged and vulnerable to weather shocks compared to men (Asfaw and Maggio, 2018; De Pinto et al., 2020; Islam, 2018; Naz and Saqib, 2021), demonstrate a better ability to recover and bounce back from flood shocks in the long run. This suggests evidence of a mismatch between women's vulnerability and their ability to recover from extreme weather shocks, especially when they are provided with the right support (i.e. assistance, income diversification strategies) and when they have authority within the household (i.e. headship) and when they own land.

The aim and relevance of this study lie in its comprehensive approach to understanding how gender characteristics influence the recovery of rural households affected by floods over time. This is particularly important for designing gender-sensitive interventions and policies that address the vulnerabilities and strengths of different household members, especially in regions prone to weather shocks like Bangladesh (IPCC, 2019; World Bank, 2014).

I organize the remainder of this paper as follows: Section 2 provides a review of the literature. Section 3 explains the conceptual framework and identifies the research questions. Section 4 describes the data and methods. Section 5 discusses the results. Section 6 concludes and proposes policies.

1.2 State of the art

I analyze two research branches that this work contributes to. The two branches respectively study (1) the gender-differentiated impact on households' food and nutrition security and (2) the effects of weather shocks on households' food and nutrition security. In doing so, I aim to point out that these two literature strands have been carried out separately and do not combine all of the broad groups of variables: weather shocks, gender, coping strategies, resource allocation, food and nutrition security. Additionally, I wish to emphasize that the results discussed in this section are at the household level.

1.2.1 Gender-differentiated household outcomes

The first strand of literature that I am interested in explores the gender differences in food and nutrition security, shedding light on the various dimensions of this complex issue. Gender is a critical factor that influences well-being due to unequal gender dynamics and social norms.

Gender roles and responsibilities significantly shape access to nutritious foods, disadvantaging women. Studies by Agarwal (2002) and Doss (2013) emphasize that women often bear the responsibility of procuring and preparing food for the household. These roles can limit women's time and decision-making power, affecting their ability to access diverse and nutritious diets. These disadvantages are exacerbated in the presence of weather shocks, making women additionally vulnerable. Consequently, men and women experience different levels of vulnerabilities, coping mechanisms, and adaptation measures in response to weather shocks to ensure their livelihood and food security (Islam, 2018; Lambrou and Nelson, 2010). In Malawi, households where women are responsible for the land are negatively impacted by weather shocks in terms of total consumption, food consumption, and daily caloric intake (Asfaw and Maggio, 2018).

Previously, scholars provided gender-differentiated results by including the gender of the household head as a control variable (i.e. a dummy variable representing the gender of the household head) (Sekabira and Nalunga, 2020; Nwaka and Akadiri, 2020). Others include variables such as women's decision-making power through synthetic indexes such as the Women's Empowerment in Agriculture Index (WEAI) (De Pinto et al., 2020; Hossain et al., 2021; Sraboni et al., 2014). In the context of analyzing gender-differentiated household food and nutritional outcomes, different indicators have been utilized to measure food security: the Household Dietary Diversity Score (HDDS) (Sekabira and Nalunga, 2020; Sraboni et al., 2014); the Food Consumption Score (Hossain et al., 2019; Lentz et al., 2019; WFP, 2008); calorie availability, Body-Mass Index (BMI) (Sraboni et al., 2014), and other food consumption indices (Demeke et al., 2011; Mehar et al., 2016).

1.2.2 Weather shocks and household well-being

The second strand of literature that I contribute to studies the impact of weather shocks on household well-being. Climate-related hazards are becoming more frequent (IPCC, 2021, 2012). Farmers, who rely on rainfall for their livestock and crop production, are particularly vulnerable to these shocks (Cohn et al., 2017). The level and variability of rainfall are important determinants of persistent food insecurity and vulnerability (Demeke et al., 2011). For example, excess rainfall caused massive flooding that hit rural Bangladesh in 2014. This flood led to a decrease in income and food expenditure (Giannelli and Canessa, 2021) and an increase in migration. Strategies such as the improvement of rice crops (i.e. switching rice variety, replanting rice, cultivating salinity-tolerant rice) and crop differentiation (i.e. the conversion of rice paddy to fish production and the use of different crop varieties in alternate years) are also adopted by households against rainfall shocks in Bangladesh (Maya et al., 2019).

Other weather anomalies are widely analyzed in terms of household well-being and resilience. In Tanzania, there is evidence of resilience thresholds in the presence of exogenous temperature-induced weather disturbances. In this context, the education of the household head, the number of children in the household, the amount of land owned, and the poverty level are significant determinants of an above-threshold resilience capacity—measured through food consumption (d'Errico et al., 2019). Other scholars investigate factors mediating the impacts of weather shocks on well-being. A common factor is asset depletion, as it moderates the effect of weather shocks on households' dietary diversity by reducing the likelihood that households exhibit adverse consumption habits, cushioning the effect of health shocks on the diversity and frequency of household food consumption. Similarly, savings help to moderate the effect of weather shocks on household dietary diversity and of price shocks on the diversity and frequency of food consumption (Ansah et al., 2021).

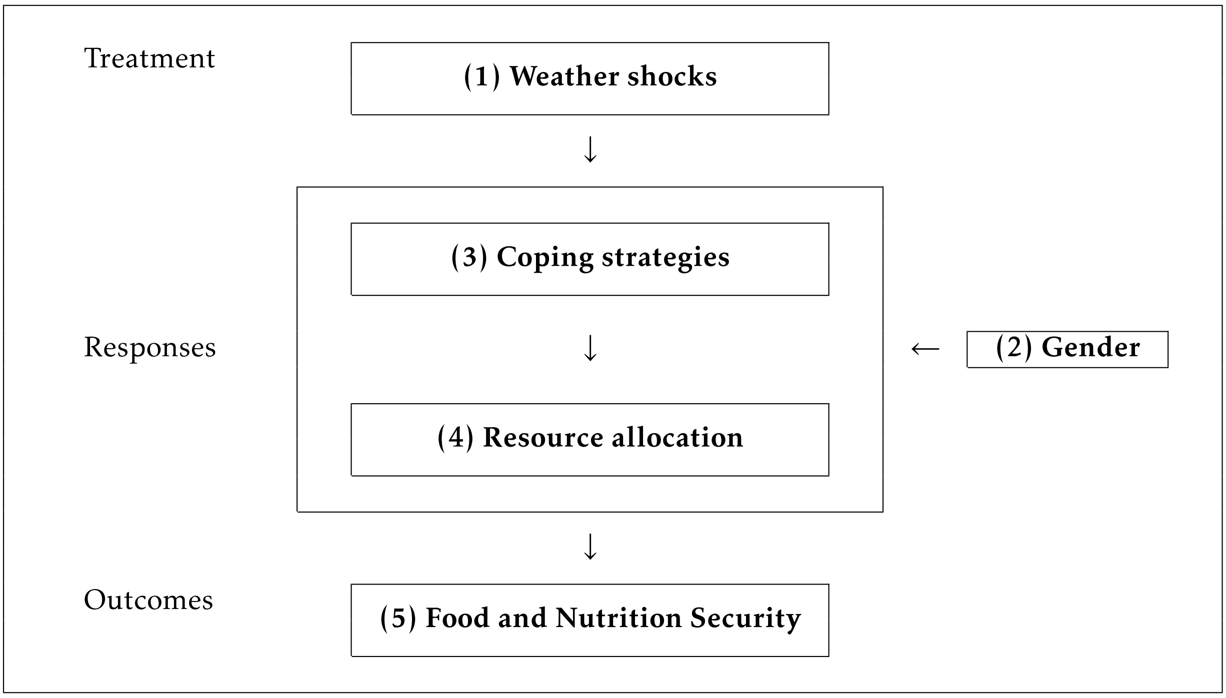
1.3 Conceptual framework

The two strands of literature on gender-differentiated household outcomes and on weather shocks and household wellbeing generally constitute two separate research lines. The innovative contribution of this work is to (a) combine these two separate strands of literature, and (b) analyze the different components that link weather shocks with food and nutrition security responses, controlling for gender-mediated factors. In our conceptual framework, I identify five main sets of variables (Table 1.1): (1) weather shocks, (2) gendered characteristics, (3) coping strategies, (4) resource allocation and (5) food and nutrition security (FNS). In this section, I review the literature on the different relationships among these sets of variables. This literature conducts analysis at the household, intra-household or individual level. This allows us to unpack the general questions, by pointing out different relevant aspects.

1.3.1 Effects of weather shocks

Climate change-induced shocks are going to increase over the next years (FAO, 2021). Elevated temperatures, rainfalls, droughts, sea-level rise and soil deterioration, already have and will continue to impact both the quantity and quality of food. Weather shocks can also impact the nutritional quality and diversity of diets. Studies by Reynolds et al. (2015) and Turner et al. (2015) suggest that reduced agricultural productivity can lead to a decline in dietary diversity, as households may rely on a narrower range of less nutritious foods. This, in turn,

Table 1.1: Sets of variables in the conceptual framework



can contribute to malnutrition and deficiencies in essential nutrients. These consequences constitute an enormous threat to food security in terms of availability, accessibility and usage, which hinder the achievement of SDG 2 in particular. Given the relevance of this phenomenon, the consequences of weather shocks, such as extreme rainfall and drought, on food security and nutrition have been studied by various authors.

The effects of rainfall have been analysed at the household and individual-level. A the household-level, Demeke et al. (2011) find negative effects of rainfall shocks and rainfall variability on the food security and vulnerability of smallholders in rural Ethiopia. Since, the authors conduct the analysis at the household level, they fail to capture individual effects within the household or the gender-dimension. Recently, Islam et al. (2022a)[3] investigated whether extreme climatic events (flood, drought, cyclones) have an heterogeneous impact on Bangladeshi households' food consumption, suggesting negative short-run effects and no significant long-run effects. Furthermore, flooding increases the number of food-insecure households and exacerbates malnutrition, particularly among vulnerable groups such as children (Agabiirwe et al., 2022). These impacts are more pronounced in regions with less developed infrastructure and limited resources to cope with such disasters. At the individual level, floods can lead to long-term health impacts due to compromised nutrition and increased vulnerability to diseases, further exacerbating food insecurity (Hadley et al., 2023).

[3]The authors use all rounds of BIHS household panel data, but they conduct a diff-in-diff analysis, examining the effects separately for two rounds at a time.

In the aftermaths of weather shocks, the affected population often resorts to the adoption of strategies to recover and adapt from the adverse shock. The coping strategies adopted by households in response to weather shocks can significantly influence their overall wellbeing (Hoque et al., 2020). Research by Islam et al. (2022b) and Nguyen et al. (2013) indicates that these strategies may include reducing portion sizes, skipping meals, or consuming less preferred foods. While these coping mechanisms can provide short-term relief, they can also have long-term negative impacts on dietary quality, quantity and nutrition. Other adaptation strategies are related to agricultural practices, especially for rural agriculture-dependent population. The main strategies of farmers are cultivation of salinity-tolerant rice, rice variety switching, replanting of rice, changing planting dates, conversion of rice paddy to fish production and use of different crop varieties in alternate years. Adaptation is positively influenced by family size, annual income, farmer-to-farmer extension and access to subsidies; and negatively influenced by farm size and credit access (Maya et al., 2019). Furthermore, households affected by massive floods, may decide to migrate. Giannelli and Canessa (2021) show an increase in migration (mostly internally) and remittances, subsequent to a massive flooding that hit Bangladesh in 2014. To follow up on this recent work, further research could study the effects of succeeding floods that hit Bangladesh in the subsequent years. This could allow to detect if the households that were hit by the 2014 flood, are more prepared to adapt and recover from the subsequent floods, i.e. if there is a "learning-by-doing" behavior of the affected populations, due to the development of an adapting capacity to shocks. To secure and improve the level of food and nutrition security, households implement different mechanisms. There is evidence of a positive association between dietary diversity and many coping strategies: farm diversification, market access, commercialization of farms and diversification of income towards off farm sources (Islam, 2018). There is in fact evidence of a positive association between farm production diversity and dietary diversity (Sekabira and Nalunga, 2020).

1.3.2 Gender-differentiated effects

Females household members are often disadvantaged when it comes to resource allocation among household members, extending to food consumption, dietary adequacy and nutrition. The intra-household allocation of food resources can perpetuate gender disparities in nutrition. Research by Quisumbing and Maluccio (2003) and Hoddinott and Wiesmann (2008) highlights that in many contexts, men and boys receive priority when it comes to food distribution within households. This can lead to women and girls having inadequate access to essential nutrients, contributing to higher rates of malnutrition among them. Harris-Fry et al. (2018) study the intra-household food and nutrient allocation in rural Nepal, showing that foods and nutrients are allocated inequitably within households, with a clear male advantage. Male household heads consume more animal-source foods, and have the highest dietary adequacy, whereas women eat more low-status foods and have lower dietary adequacy. Additional insights into the existing gender food inequality in the context of household decision making are provided by Zingwe et al. (2021). The authors examine the effects of intra-household power dynamics particularly on food security and household nutrition. They find gender disparities, particularly in food nutrition between female-led and male-led households. These disparities derive from male-headed households having better nutrition than female-headed households; households with a female-dominant voice having better nutrition than those with a male-dominant voice; and male-headed households with female-dominant voice having better nutrition than other households.

At the individual level, there is evidence of intra-household disparities due to an unequal distribution of food within Nigerian households (Akerele, 2011). This is one major factor that promotes the lingering under-nourishment among household members. Male and female school-age children are the most severely affected by malnutrition, while adult male members are most favoured in terms of food calorie allocation. Household income and household farm production are mechanisms that influence the relative distribution of food calories among household members.

Another way of studying how gender-related factors play a role for wellbeing, is to analyse the role of the empowerment of women within the household. Sraboni et al. (2014) does this by analysing the effect of women's empowerment in agriculture on calorie availability, dietary diversity and adult BMI. The authors find that increases in women's empowerment are positively associated with calorie availability and dietary diversity at the household level. Additionally, the results suggest that intra-household trade-offs may exist, given that male nutrition is negatively impacted by women's credit access and group membership. Existing research has shown the importance of women's empowerment within the household to improve not only food and nutrition security, but also intra-household resource allocation (Kiewisch, 2015). The decision-making power between two female and male spouses is often not balanced. Acosta et al. (2020) and Bonis-Profumo et al. (2022) present significant gender-power differences. They find that for many women, a joint decisions requires their husband's consent, without which they would not proceed with selling livestock, purchasing food, or with the adoption of agricultural practices and with consumption expenses. Women's unequal bargaining position is shown to be influenced by social norms on the gendered division of labour, and by men's role and framing as income generators. Women's empowerment is documented to influence agricultural technical efficiency and spending choices, the sourcing and preparing of foods, diet quality and dietary diversity, and households' nutritional outcomes. Hossain et al. (2021) provide hopeful results for the role of women's empowerment in agricultural households because they suggest that their empowerment improves food security in terms of children's intake of nutrients, in Bangladesh. Particularly, decisions relative to the allocation of resources such as input into production are important for food consumption. However, with an advantage for boys with respect to girls, which shows a gender imbalance on food allocation.

1.3.3 Weather shocks and gender-differentiated effects

Weather shocks, such as droughts, floods, and extreme temperature events, have been recognized as critical drivers of agricultural production variability and livelihood disruption in many regions. These shocks can have profound effects on households' ability to cope, allocate resources, maintain food security, and ensure adequate nutrition. Importantly, these effects may differ based on gender, given the varying roles and responsibilities of men and women within households and communities. This section aims to explore the gender-differentiated impacts of weather shocks on coping strategies, resource allocation, food security, and nutrition. Men and women farmers in the Gloabl South experience different vulnerabilities and coping mechanisms and adaptation measures in response to climate change risks. Gender gaps exists in terms of access to resources, information, services, technologies, training, finance. These gaps consequently respectively enable or constrain men and women to adopt climate-smart agriculture and practices (Paris and Rola-Rubzen, 2018), differnetly impacting their wellbeing. Existing research has studied the effects of weather shocks on the adoption of coping strategies, on the allocation of resources and on FNS, taking into account gender characteristics.

Gender roles often determine how men and women engage in agricultural activities, income-generating work, and household management. Studies by Doss et al. (2018) and Kabeer (2005) highlight that women's responsibilities in childcare, water collection, and cooking make them particularly vulnerable to the impacts of weather shocks, as these tasks can become more challenging during extreme events. On the other hand, men's involvement in crop cultivation and livestock management can also be disrupted.

The impact of weather shocks on food and nutrition security has been studied through the lens of the household head's or the land owner's gender. Nwaka and Akadiri (2020) find a rising probability of food insecurity, with female-headed households being relatively more food insecure than male-headed households. The gender-differentials relative to the ownership of land are studied by Asfaw and Maggio (2018). The authors conduct a gendered-analysis on the effects of weather shocks on household food security in Malawi, based on the gender of the household's crop owner. Their results show that temperature shocks result in severe consequences for households where women are the sole responsible of the land, due to a reduction in total consumption, food consumption and daily caloric intake. Additionally, the nutrition of men and women is also differently impacted by weather shocks. Women's dietary intake is often compromised during these shocks, as they prioritize their families' food consumption over their own, resulting in increased malnutrition (Block et al., 2004; Jones, 2017)

Moreover, gendered differences emerge also in the adoption of coping strategies. Women tend to resort to off-farm income generation or informal activities during shocks, which can affect their nutritional intake and well-being. Men, meanwhile, may migrate for wage labor, impacting both their own nutritional status and the care responsibilities they leave behind (Azzarri et al., 2015). Mehar et al. (2016) explore intra-household dynamics and coping strategies differentiated by gender, for Indian farmers affected by climate change. They suggest that male farmers are more likely choose the coping strategy to adopt. Indeed, the gender of the decision-maker is significantly associated with the choice of strategies such as crop rotation and eating less: male decision-makers are more likely to select the option of eating less for all family members. Another prominent coping mechanism adopted is to find alternative urban employment and reduce the food consumption level. Furthermore, when exposed to agriculture extensions and trainings, farmers are more inclined to choose the appropriate coping mechanisms. However women are disadvantaged in this choice, as they have poor access to these services (i.e. information on climate change and appropriate response options). This contributes to women farmers' lower adoption rates of improved practices and technologies (Bryan et al., 2017).

To summarize, weather shocks have gender-specific implications for coping strategies, resource allocation, food security, and nutrition within households. Recognizing and addressing these differentiated effects is crucial for building resilient communities and ensuring equitable well-being in the face of climate change and environmental uncertainty. Further research is needed to better understand the underlying mechanisms driving these dynamics and to inform effective policy interventions that promote gender equality and household resilience.

The analysis of the literature carried out in Section 3 shows that current research has focused on the following relationships:

a) the effects of gender-characteristics on:

  – the allocation of resources, i.e. relationship 2-4 (Acosta et al., 2020; Anderson et al., 2017; Bonis-Profumo et al., 2022; Kiewisch, 2015; Kosec et al., 2022; Molina et al., 2022), or

  - food and nutritional outcomes, i.e. relationship 2-5 (Akerele, 2011; Harris-Fry et al., 2018; Mwaseba and Kaarhus, 2015; Sraboni et al., 2014; Zingwe et al., 2021),

  in both cases not including weather shocks or in contexts not affected by extreme weather events;

b) the consequences of weather shocks on:

  - coping strategies, i.e. relationship 1-3 (Giannelli and Canessa, 2021; Hasan et al., 2016; Maya et al., 2019),

  - food and nutritional outcomes, i.e. relationship 1-5 (Aguilar and Vicarelli, 2011; Block et al., 2004; Demeke et al., 2011; Dimitrova and Bora, 2020; Nsabimana and Mensah, 2020; Rabassa et al., 2014; Tiwari et al., 2017),

  not controlling for gender-mediated characteristics;

c) the effects of both weather shocks and gender characteristics on:

  - the adoption of coping strategies, i.e. relationships 1-2-3 (Mehar et al., 2016; Mishra and Pede, 2017; Paris and Rola-Rubzen, 2018),

  - the allocation of resources, i.e. relationships 1-2-4 (Islam and Sharma, 2021), or

  - food and nutritional outcomes, i.e. relationship 1-2-5 (Asfaw and Maggio, 2018; Nwaka and Akadiri, 2020); d) the effects of coping strategies on food and nutritional outcomes:

d) the effects of coping strategies on food and nutritional outcomes:

  - either in a weather shock context, i.e. relationships 1-3-5 (Ansah et al., 2021),

  - or mediated by gender characteristics, i.e. relationships 2-3-5 (Islam, 2018; Sekabira and Nalunga, 2020).

This paper aims at bringing together existing research on gender-differentiated household outcomes and on weather shocks effects on household well-being. The effects of weather shocks and coping strategies on food security mediated by gendered characteristics have been studied only by (Mutenje et al., 2016), but at the household level in Malawi. Our aim is to take the existing research one step forward by analyzing the relations between these factors at both the household and individual levels in Bangladesh. I implement this analysis using the three rounds of the Bangladesh Integrated Household Survey (BIHS), which provide a country representative individual panel dataset, covering the years 2011-2018 (cfr. Section 1.3.4). So far this dataset has been used only by Matsuura (2021) to study crop diversification as a coping strategy to recover from weather shocks, without considering gender dimensions and food and nutritional outcomes; and by Islam et al. (2022b) who investigate whether extreme climatic events (flood, drought, cyclones) have a heterogeneous impact on each region's agriculture. In doing this, our research aims at providing policy insights that can inform the design of gender-sensitive interventions in the wake of weather shocks, enhance the adaptation to extreme weather events and improve food and nutrition security of vulnerable groups.

Based on our conceptual framework, this study aims to address several important research questions. First, it investigates *"what is the effect of flood intensity on household food security and individuals' nutrition in rural Bangladesh?"*. This question explores the core impact of flood events on the well-being of households and individuals.

Next, we consider *"how do gender characteristics shape these effects?"*. Specifically, we examine how the gender of the household head, the gender of household members, and the gender of the landowner influence the relationship between flood intensity and food security and nutrition.

Finally, we seek to understand *"what are the underlying mechanisms driving these effects?"*. This question focuses on uncovering the pathways through which flood intensity impacts food security and nutrition, providing a deeper understanding of the dynamics involved.

1.3.4 Data

To address the research questions, I exploit two sources of data. The Bangladesh Integrated Household Survey (BIHS) is a panel dataset composed by three survey rounds (2011-12, 2015 and 2018-19), collected by the International Food Policy Research Institute (IFPRI) (Ahmed, 2011; International Food Policy Research Institute (IFPRI), 2015, 2018). The BIHS is a nationally representative survey, administered with annual temporal resolution to the same sample of households in all three rounds. This allows to create a nationally representative panel dataset covering the years 2011-2019. The final sample includes the geo-located households that were present in all three survey waves, which causes a drop of around 30% of the observations with respect to the initial sample (cf. Table A3 for an attrition test comparing baseline characteristics). The final sample[4] is composed by 4586 households in each round (Table A1). Figure 1.1

[4]The data selection process was as follows: In round 1, the BIHS surveyed 6503 households. Of these, 6,040 households were also present in round 2. The number of households surveyed in rounds 1, 2, and 3 was 4604, resulting in an attrition rate of 29.2% from round 1 to round 3. The final sample for analysis consists of 4586 households, leading to a total attrition rate of 29.47% from round 1 to the final sample.

shows the households' geolocation. What makes the dataset particularly suitable for this study are the extensive modules on food security, agriculture production, technology, migration, remittances, transfers, coping strategies, anthropometrics, decision-making power and women empowerment. The high degree of precision of the BIHS data allows to conduct an in-depth analysis of household's food security and individuals' nutritional response to weather shocks. In order to measure the impact of flooding events, I use the geo-localized flooding data provided by NASA (NASA, 2022), and match it with BIHS data through household coordinates (International Food Policy Research Institute (IFPRI), 2017).

The BIHS has been used by various authors over the years. The first and second round of survey data, collected in 2011/2012 and 2015 respectively, are the most used by authors up to this day. Given its wide range of extensive modules, it has been used to analyse different topics: agricultural production, farm and non-farm income, technical efficiency (Mondal et al., 2021), nutrition, food security (Islam et al., 2018; Brown et al., 2021; Hossain et al., 2021), intra-household food allocation (Hossain et al., 2021), consumption inequality (Brown et al., 2021), labor force participation (Ehsan and Akter, 2020), women's empowerment in agriculture (Anik and Rahman, 2021; Hossain et al., 2021; Sraboni et al., 2013), gender, livelihood, unpaid time allocation (Islam and Sharma, 2021), returns to education (Mamun et al., 2021), shocks (Ehsan and Akter, 2020), climate change (Matsuura, 2021), natural hazards (Petrova, 2021), climate mitigation, coping strategies (Ehsan and Akter, 2020), climate smart agriculture, crops, livestock Sapkota et al. (2021), crop diversification (Matsuura, 2021), migration (Giannelli and Canessa, 2021; Petrova, 2021; Romano and Traverso, 2020, 2019).

These papers have analysed different aspects such as the effects of farm diversification on dietary diversity (Islam et al., 2018); the effects of adverse shocks on female labor force participation (Ehsan and Akter, 2020); the within-household inequalities in terms of consumption and poverty (Brown et al., 2021); the effects of rural non-farm income on technical efficiency (Mondal et al., 2021); the effect women's empowerment in agriculture on production efficiency (Anik and Rahman, 2021); the impact of women's empowerment on children's food security (Hossain et al., 2021); the impact of shocks on the total time allocated toward unpaid activities by women (Islam and Sharma, 2021); the impact of floods on households' internal migration (Giannelli and Canessa, 2021; Petrova, 2021), international migration, income and expenditures (Giannelli and Canessa, 2021). To our knowledge, only Matsuura (2021) and Islam et al. (2022b) have previously combined the three rounds of BIHS data, respectively to study farmers' crop diversification strategies adopted in response to shocks and to investigate the impact of extreme climate events on agriculture.

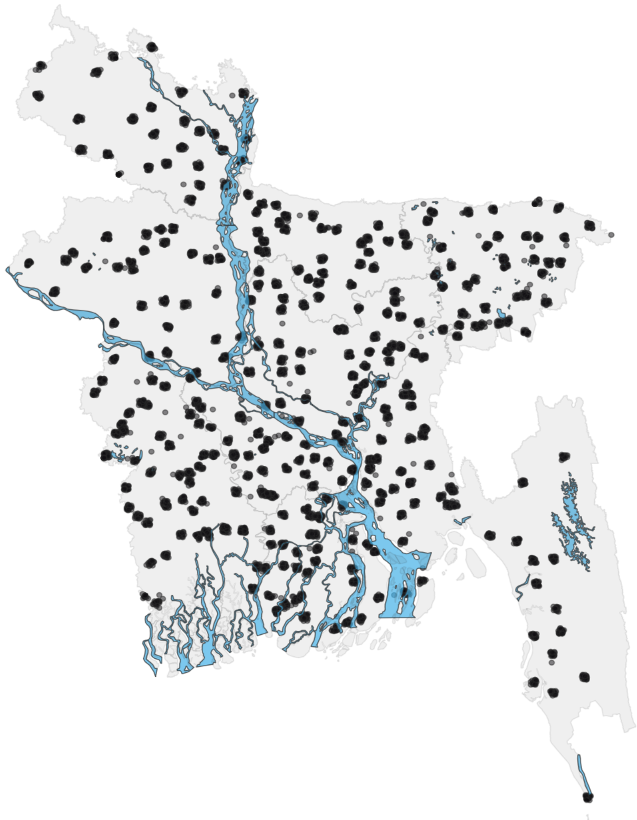


Figure 1.1: Geo-location of BIHS households

1.3.5 Variables

Measuring floods

Between 2011 and 2019, Bangladesh has experienced two severe flooding events (in 2014 and 2017) that affected around 3 million people, of which 275,000 were displaced. These massive floodings hit most severely the northeast part of Bangladesh, and damaged more than 10,000 acres of crops (ACAPS, 2018; IFRC, 2015). Given the timing of BIHS data collection, it is possible to analyze the impact of the shocks at different time periods after the shock occurred. In order to identify the areas and the households affected by the flood, I match the geo-localized BIHS data with flood remote sensing data. I use the NASA flooding maps collected by the "MODIS Near Real-Time Global Flood Mapping Project"[5] (NASA, 2022). The MODIS (Moderate Resolution Imaging Spectroradiometer) instrument produces global daily surface and flood water maps at approximately 250-m resolution, in 10x10 degree tiles. The water detection algorithm elaborates and analyzes colors combining Band 1, Band 2, and Band 7 to identify pixels as water. I utilize the MFW (MODIS Flood Water) product images, which removes from MSW (MODIS Surface Water, which gives all land-based water – with a buffer

[5] Website: https://www.earthdata.nasa.gov/learn/find-data/near-real-time/modis-nrt-global-flood-product

into oceans – that was observed in the given product) a reference or expected water layer, such that the remaining water is likely flood. I adopt composite images of the previous 14 days' 3-day product, to provide a recent-historical view of flooding and surface water extent. The 3-day time-span of the image largely overcomes the patchiness issue due to cloud coverage which is supposedly thick during floods, thus providing more detailed data. The products of 14 days are more effective because they include observations for a longer period and better able to capture the whole extensions of the flooded areas (Nigro et al., 2014). Given the location and period constraints, MODIS flood data is the best option available for studying flood extension (Giannelli and Canessa, 2021; Gröger and Zylberberg, 2016).

To identify the households affected by the floods, I match the households' BIHS geo-locations with the flood remote sensing data. For each household, I calculate the intensity of the flood as the percentage of the "inundated" pixels in the 5-km radius around the households' coordinates[6]. I construct two treatment variables capturing the intensity of the flood, based on the timing of the flood events: the flood immediate and the flood delayed variable. These variables capture the intensity of the flood respectively 3-5 months and 15-17 months before the data was collected in the following BIHS round (in August 2013, 2014, 2017, 2018). I use the flood variables to capture respectively the short-run and long-run effects of the floods on our outcomes of interest.

The impacts of floods in Bangladesh vary in the short-run and long-run, affecting economic development, agricultural productivity, and social structures differently. Understanding these distinct impacts is crucial for effective policy formulation and disaster management. In the short-run, floods primarily disrupt daily life and economic activities. Immediate consequences include the destruction of property and crops, leading to significant economic losses (Reid et al., 2012). People are often displaced from their homes, resulting in a humanitarian crisis, while floods can also lead to the spread of waterborne diseases and exacerbate existing health problems. Local markets are disrupted, causing shortages of essential goods and price spikes. In contrast, the long-run impacts of floods are more complex and multifaceted. Over time, communities may adapt to recurrent flooding through improved infrastructure, diversified livelihoods, better planning, and assistance. However, frequent floods can also deter investment and slow economic growth (Banerjee, 2010). The effects on agricultural productivity can be both positive and negative. While floods initially destroy crops, they can also deposit nutrient-rich silt, which may enhance soil fertility in the long run. Additionally, long-term ex-

[6] I use the qGIS software to elaborate the NASA flooding maps data, and to calculate the flood intensity around each household I use the *zonal statistics* tool.

posure to floods can lead to changes in social structures and institutional practices, such as the development of more robust community networks and better disaster management policies.

The short-run and long-run impacts of floods in rural Bangladesh are interconnected but not perfectly correlated. While short-run impacts often provide a precursor to the long-term consequences, they do not always predict them accurately due to the adaptive capacities of communities and varying external factors such as government interventions and international aid. Reid et al. (2012) explore the health impacts of climatic variability, highlighting how short-term floods exacerbate health crises, which can have lingering effects on public health systems. Banerjee (2010) discusses the short-term and long-term economic impacts of floods, including changes in agricultural productivity and rural incomes. Islam et al. (2022b) highlights both short-term and long-term impacts of flooding, including economic resilience and adaptation strategies. Therefore, it is crucial to capture the intensity of floods and to separate between the short run and the long run effects. Understanding these impacts can guide more effective and sustainable development interventions. The timeline of the floods and the three rounds of our panel dataset are summarized in Table 1.2. Table A8 shows the descriptive statistics of flood variables.

Table 1.2: Timeline of BIHS panel and flood events

<table>
<tr><th>First wave</th><th>Flood</th><th>Second wave</th><th>Flood</th><th>Third wave</th></tr>
<tr><td rowspan="2">Nov. 2011 - Mar. 2012</td><td>Aug. 2013 (delayed effect)</td><td rowspan="2">Jan. 2015 - May 2015</td><td>Aug. 2017 (delayed effect)</td><td rowspan="2">Nov. 2018 - Apr. 2019</td></tr>
<tr><td>Aug. 2014 (immediate effect)</td><td>Aug. 2018 (immediate effect)</td></tr>
</table>

Measuring gender characteristics

I examine the effects of floods in terms of gender-related characteristics. In particular I test if I find differential results in terms of the gender of the household head and gender of the crop owner. The gender of the household head is a relevant factor for assessing gender-differentials effects on intra-household resource distribution (Hossain et al., 2021). I construct a variable indicating the head's gender as a binary variable, taking value of 1 if the head is female and 0 if the head is male (descriptive statistics are presented in Table A2-A5. Another relevant characteristic is the gender of the household's member responsible for the land. In contexts of weather shocks, households with a female responsible of land, report a lower level of food security, compared to households where the responsible is a male (Asfaw and Maggio, 2018). Builiding on this insightful work, I construct a categorical variable taking value =1 if all the crops owned by the household are owned by a female member; =2 if the crops are owned by a male member; =3 if the crops are owned jointly or if some are owned by females and some are owned by males; =0 if the crops are owned by others (i.e. government, other institution, temporary user right). The descriptive statistics are presented in Table A8, for each panel round.

Measuring food and nutrition security

Based on previous research on food security and nutritional outcomes, I use the following FNS indicators: Food Consumption Score, Household Dietary Diversity Score and Household Hunger Score, to measure household food security; and the Body Mass Index to measure individual nutrition.

To measure household food security I construct three widely acknowledged indexes: the Food Consumption Score (FCS), the Household Dietary Diversity Score (HDDS) and the Household Hunger Score (HHS). The FCS is a frequency-weighted dietary diversity score, calculated using the frequency with which a household consumed eight food groups (staples, pulses, vegetables, fruits, meat/fish/egg, milk, sugar and oil) with a 7-day recall from the date of the survey (Hossain et al., 2019; Lentz et al., 2019; WFP, 2008).

The HDDS is primarily a diet quality indicator that captures the number of food items consumed by an individual on the reference day (Hoddinott and Yohannes, 2002; Hossain et al., 2019; Lentz et al., 2019; Sekabira and Nalunga, 2020; WFP, 2008).

The HHS is created following the original definition and measurement guide, developed by Ballard et al. (2011), which was later applied in the context of Bangladesh by Smith and Frankenberger (2018). The HHS, is an index constructed from the responses to three questions regarding people's experiences of acute food insecurity in the previous four weeks. Namely, "There was no food to eat of any kind in the household because of lack of resources to get food"; "Any household member went to sleep at night hungry because there was not enough food"; and "Any household member went a whole day and night without eating anything because there was not enough food". The survey respondents indicate whether or not they or another household member experienced the circumstance in question and, if yes, how often in the last 30 days (rarely, sometimes or often). A score ranging from 0 to 6 is then calculated based on these frequency responses. A prevalence of hunger can be calculated as the percentage of households whose score value is greater than or equal to two, representing "moderate to severe hunger".

To measure household members' individual nutrition I construct anthropometric measures for adults and children. The body mass index (BMI) is anthropometric measure of the nutritional status, that has become acknowledges as the best way of identifying changes in adults' well-being. It is given by the weight (in kilograms) divided by the height (in meters) squared. The BMI can take values between 15 and 40, with the following classification (Tan, 2004): if the BMI is below 16 the individual is classified as having severe chronic malnutrition; if the BMI is between 16-17.5, it indicates chronic malnutrition with wasting; if the BMI is between 18.5-25 it is normal; if the BMI is between 25-30 the individual is overweight; and if the BMI id above 30 the individual is classified as obese. Since I are interested in the effect of floods on undernutrition, I focus our analysis on individuals whose BMI indicates a normal, chronical or severe chronical malnourishment. I therefore subset our sample to those individuals whose BMI is equal or below 25, and I drop those whose nutritional status is classified as overweight or obese (BMI>25). This allows us to interpret an increase in BMI as a positive effect in terms of nutrition.

Given the nature of the aforementioned food and nutrition security variables, I interpret i.e. a positive coefficient of FCS, HDDS and BMI a negative coefficient of HHS, as an improvement in food security (conversely a negative coefficient FCS, HDDS and BMI and a positive coefficient of HHS, as a decrease in food security).

Descriptive statistics of FNS variables are presented in Table A6, for each panel round. Given the definitions of our outcome variables, I expect respectively the FCS, HDDS and BMI to decrease and HHS to increase, in the aftermaths of flood shocks.

Measuring controls

Following previous research, I include control variables, which I believe to be relevant in testing the relationships between weather shocks and food-nutritional outcomes. Most individuals adopt strategies to cope with the consequences of weather shocks, to adapt and reduce the likelihood and magnitude of the event's harmful effects on their wellbeing (IPCC, 2007). These strategies usually involve adjustments in behavior, resources and technologies. The degree of adaptation can be highly heterogeneous across and within societies or localities, and it is differentiated by age, class, gender, health and social status (Adger et al., 2007). For these reasons, I account for individual members' age, household head's education, dependency ratio, the number of different crops grown by the household, the co-residence of mother-in-law in the household, exposure to shocks (income, and death of min earner), area of land owned (Hossain et al., 2021). I additionally control for variables that represent various ways that households deploy to cope with negative stressors (Maya et al., 2019): the level of wealth, the share of household members involved in agricultural-earning activity, the cash assistance (converted in PPP17) and rice assistance (in kg) received in the previous year at the district level from Social Safety Net Programs targeted at enhancing food security and nutrition, remittances received, the migration of a member, livestock, soil types, percentage of rice consumed by the household coming from its own production, uses of plots, crop variety cultivated. I also include geographical dummies for divisions, the largest administrative unit in Bangladesh (Hossain et al., 2021), and for the month of interview to account for seasonal changes. More details on the variables' construction and descriptive statistics are presented in Tables A2-A5.

1.3.6 Identification strategy

Different approaches have been used to analyse the research questions similar to ours i.e. probit models Ansah et al. (2021); Ehsan and Akter (2020); Mishra and Pede (2017), multivariate probit models (Mehar et al., 2016; Nwaka and Akadiri, 2020; Sekabira and Nalunga, 2020), tobit model (Matsuura, 2021), multivariate tobit (Nwaka and Akadiri, 2020), OLS models (Hossain et al., 2021; Sraboni et al., 2013), binary logistic regression (Maya et al., 2019), conditional fixed effect Poisson model (Islam et al., 2018), linear regression and panel data regression models (Hasan et al., 2016; Sekabira and Nalunga, 2020), multiple linear regression model (Islam and Sharma, 2021), difference-in-difference approach (Block et al., 2004; Giannelli and Canessa, 2021), maximum simulated likelihood estimation of a multinomial endogenous treatment effect model (Mutenje et al., 2016) and recursive models (Sekabira and Nalunga, 2020).

Historically, intra-household level models – collective models (Chiappori, 1988), exchange models (Apps and Rees, 1996) and bargaining models (Anderson and Eswaran, 2009) – have assumed that individual household members have unitary preferences. The standard unitary model follows the assumption of equal resource allocation within the household, and that resources are always pooled at the household level (Becker, 1965). However, further evidence shows that this assumption is not always correct, because inequalities can exist among the members of the same household. There is an asymmetric distribution of income and time use between females and males, and more generally among household members. Through household-level analysis, the disadvantaged family members are often wrongly classified, particularly are children, orphans (Evans and Miguel, 2007), girls (Jayachandran and Kuziemko, 2011), and widows (Djuikom and van de Walle, 2018). Given the limitations of unitary household models, to correctly evaluate the well-being of household members, I need to estimate a model specification that accounts for individual effects of members within the same household.

To investigate the relationship between weather shocks and food and nutritional outcomes accounting or not for gender characteristics, different models have been previously employed, namely the multivariate tobit, probit, and OLS regression models. Nwaka and Akadiri (2020) investigate the effects of floods, droughts and gender characteristics on food insecurity in Ethiopia and Nigeria. Their outcome variable is measured through a latent dummy variable for food (in)security, and they analyse it through multivariate tobit and probit models using household cross-sectional panel data. Instead, Sraboni et al. (2014) use an OLS regression to analyse the effect of women's empowerment in agriculture on calorie availability, dietary diversity and adult BMI – using only the first round of BIHS data. Nsabimana and Mensah (2020) use a an OLS with fixed effects to study the impact of adverse weather shocks on child anthropometrics, on a household panel data.

In the absence of selectivity biasness and endogeneity, it is appropriate to use the OLS technique to estimate the effects of our exogenous treatment Haque and Dey (2016); Khan et al. (2012); Mahmud et al. (2021). Given the panel structure of our dataset, I estimate an OLS panel fixed-effect model, with robust standard errors double clustered at the household and division level. The double-clustering allows to account for the dependence of the residuals within each division and household, with the underlying assumption that residuals are random across division and household. In other words, I allow for any autocorrelation and heteroskedasticity within each division and household. By using a "within transformation" (fixed effects), I control for household-specific unobserved heterogeneity and focus on the variation in flood intensity over time for each household. This approach isolates the time-varying impacts of floods on the dependent variables, such as food security and nutrition, and helps to better understand how households and individuals respond to immediate and delayed flood exposure. To analyze the direct effects of floods on FNS, I estimate the following model specification.

Model 1 – Direct effect:

Household-level:

$$FNS_{ht} = \beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood delayed}_{ht} + \beta_3 X_{ht} + \beta_4 D_t + \beta_5 W_t + \delta_i + \epsilon_{ht}$$

Individual-level:

$$FNS_{iht} = \beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood delayed}_{ht} + \beta_3 X_{iht} + \beta_4 D_t + \beta_5 W_t + \alpha_i + \epsilon_{iht}$$

Where FNS_{ht} is the outcome variable for each household h at time t; FNS_{iht} is the outcome variable for each individual i at time t residing in household h; $floodimmediate_{ht}$ is the treatment variable which indicates the level of flood severity that household h suffered at time t; t is the time variable (=1, 2, 3); β_1 is the treatment coefficient which is the effect of the flood severity on individual/household FNS, and is expected to be statistically different from zero ($\beta_1 \neq 0$) and negative ($\beta_1 < 0$). W_t are division fixed effects to account for changes in division characteristics over time[7]; D_t are the dummy variables of the month of interview, taking as reference January to avoid any problem of collinearity. X are individual and household socio-economic characteristics that may shape food and nutrition security: age, education of household head, dependency ratio, number of different crops grown by the household, wealth index, income and death shocks, presence of mother-in-law, share of agricultural workers, area of land owned, remittances received, migration of a member, tropical livestock units, cash and rice assistance received, soil types, share of rice consumption coming from own production, plot uses, crop variety cultivated; δ_h and α_i denote respectively unobserved households and individual specific fixed-effects which are assumed to be fixed over time and vary across households/individuals; and ϵ is the error term.

Beyond examining the household food security and nutrition, this study further analyses the gender disparity particularly in food security and nutrition, in the aftermaths of floods. In the second stage of the analysis, I investigate the relationship between weather shocks and food and nutritional outcomes accounting for gender characteristics. To identify gender-differentiated effects, scholars have employed OLS models with interaction effects. Flatø et al. (2017) use OLS fixed-effects models, to study effect of exogenous variation in rainfall on agricultural yields. To study the differential effect across types of households, they interact the explanatory variable with headship status. Sekabira and Nalunga (2020) use panel regression models for each gender of household head, to investigate associations between farm production diversity and dietary diversity, using a panel survey data from Uganda. To conduct the analysis for each gender category of land ownership (female, male, mixed/joint) Asfaw and Maggio (2018) use a OLS fixed effects model to measure the effect drought on food consumption.

To analyse the effects of flood shocks on FNS taking into account gender characteristics, I build on previous work. Specifically, I estimate two gender-models, each at the households and the individual-level. Model 2 differentiates the analysis by the gender of the household head and the gender of household member, Model 3 by the gender of the land owner. I construct

[7] The geographical dummies are collinear with the household and individual fixed effects in the full sample models and, therefore, are omitted from the regression. We expect this omission since there is no migration in our final analysis sample, meaning households did not change their location throughout the survey rounds. However, we include geographical dummies in the sub-sample analysis to account for potential changes in the head of household (e.g., from male to female) and coincidental changes in divisions during the survey period, which could result in division dummies that vary within the sub-sample.

fully-interacted OLS panel fixed-effect regression models, with robust standard errors double-clustered at the household and district level. Models 2 and 3 are fully-interacted models, which are suitable to show heterogenous treatment effects (i.e. different treatment effects for different groups). These models' specification is optimal to show different treatment effects across groups. In fact, splitting the sample is a bad way to show the heterogeneity of these. A very common use of split sample analysis is to run separate regressions and, upon observing that an estimated coefficient is i.e. significant for one group and insignificant for another group, it wrongly conclude that its treatment effect is different across groups. This is incorrect because the significance depends on other covariates as well (Zhao and Jiang, 2022). I construct these models by interacting our gender-variable(s) with all the other variables of the model. Model 2 and 3 are in fact adding to Model 1, the interaction of the gender variable which with all the variables (included in Model 1). The gender interaction terms are respectively $femaleHH_{ht}$ and $femaleHH_{iht}$ in Model 2 (for the household- and individual-level model, respectively) (Flatø et al., 2017; Sekabira and Nalunga, 2020), and $landowner_{it}$ in Model 3 (Asfaw and Maggio, 2018).

Model 2 – Gender-mediated effect (fully interacted model):

Household-level:

$$FNS_{ht} = \text{female HH}_{ht} * (\beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood delayed}_{ht} + \beta_3 X_{ht} + \beta_4 D_t + \\ + \beta_5 W_t + \delta_i + \epsilon_{ht})$$

Individual-level:

$$FNS_{iht} = \text{female}_{iht} * (\beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood delayed}_{ht} + \beta_3 X_{iht} + \beta_4 D_t + \\ + \beta_5 W_t + \alpha_i + \epsilon_{iht})$$

where *female* HH_{ht} =1 if the household head is female, =0 if male; $female_{iht}$ =1 if the individual member is female, =0 if male.

Model 3 – Land-owner effect (fully interacted model):

Household-level:

$$FNS_{ht} = \text{land owner}_{ht} * (\beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood delayed}_{ht} + \beta_3 X_{ht} + \beta_4 D_t + \\ + \beta_5 W_t + \delta_i + \epsilon_{ht})$$

Individual-level:

$$FNS_{iht} = \text{land owner}_{it} * (\beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood delayed}_{ht} + \beta_3 X_{iht} + \beta_4 D_t + \\ + \beta_5 W_t + \alpha_i + \epsilon_{iht})$$

where *land owner*$_{it}$ =1 if female household member owns all household crops (FLO), =2 if male household member owns all household crops (MLO), = 3 if joint/mixed owner of household crops (JLO)

1.4 Results & Discussion

In this section, I present and discuss the results of our analysis. I start with the analysis of the direct effect of floods, then I disentangle the analysis by the gender of the household head, household members, and landowner.

1.4.1 Direct effect of floods on FNS

The results show that floods have immediate detrimental direct effects on households' food security and adult nutrition. This is represented by the negative and significant coefficients of *flood immediate*, in Table 1.3 (full models in Table A9-A10) and is in line with previous evidence in Bangladesh (De Pinto et al., 2020; Demeke et al., 2011). In the long run, instead, the impact of the floods does not seem to be so harmful. In fact, when rural households are inundated multiple times, they are able to adapt and recover. This shows that households are able to develop an adapting capacity. This finding is in line with evidence by Giannelli and Canessa (2021) and Vitellozzi and Giannelli (2023). Evidence of positive long-run effects of floods in Bangladesh is also provided by Banerjee (2010) and Islam et al. (2022b), and in Nepal by Tiwari et al. (2017), who find a positive impact on harvests. Indeed, as stated by Islam et al. (2022b), floods have damaging effects on household food consumption in the short run (between the years 2011-2015) in Bangladesh. Conversely, in the longer run (between the years 2011-2019), households in flood-inundated areas have no severe effect on food consumption. Additionally, the agricultural lands that are inundated frequently and repeatedly over time, present benefits given by river overflows depositing mineral-rich silt (Banerjee, 2010). These minerals enrich the soil over the years, augmenting soil fertility, and floodwaters replenish the underground water table. These factors create a natural cycle of irrigation/fertilization of soil, and work together to improve agricultural productivity in the more flooded districts, in the long run. Banerjee (2010) also emphasizes the importance of the severity of the flood. It appears that only "extreme floods" are harmful to agricultural production and productivity in Bangladesh, and although severe inundations destroy crops in the monsoon season, monsoon floods act as an open-access resource in supplying irrigation input to agriculture. Additionally, the more flood-prone districts of Bangladesh are positively associated with the size of the cultivated area and with agricultural productivity; and although yield rates decline when floods arrive in "extreme" proportions, productivity increases during "normal" floods and in the post-flood months. Nonetheless, any form of assistance - monetary and in-kind - plays an important role in the post-flood recovery of households. In fact, in our sample, the monetary assistance received by households that were flooded 13+ months prior to the survey was conducted is 25% higher compared to those that were not flooded. As a matter of fact, Bangladeshi households that receive assistance cope better with weather shocks (Maya et al., 2019). To further test the relevance of cash assistance in enhancing food and nutrition security in the context of floods, I conduct an additional analysis. Results suggest that the cash assistance received in the previous year significantly improves food and nutrition security. Specifically, it increases FCS, HHDDS, and BMI (Table A19) This result confirms the fundamental role played by targeted programs in assisting vulnerable populations.

Another significant contributor to food and nutrition security is the diversification of income. Households with a high share of members working in agriculture observe a negative effect on their food consumption, dietary diversity, and hunger score. Hence, income accumulation towards the agricultural sector is not a positive factor for food security, suggesting that income diversification towards other sources of earning might be beneficial for household well-being. I further investigate and support the importance of diversifying income towards non-agricultural activities for FNS (cf. Table **??**). This result supports existing evidence on the positive association between diversification of income towards off-farm sources and household food security in Bangladesh (Islam et al., 2018).

Additional positive factors for FNS are crop varieties and plot use. The use of plots for fisheries positively contributes to the dietary diversity of the household. This finding confirms and strengthens the importance of aquaculture in Bangladesh, especially during floods. Indeed, the productivity of this country's fisheries is driven by the annual monsoonal flood pulse (Banerjee, 2010; Belton et al., 2014). When the household uses plots for non-agricultural activities, the food security improves. Additionally, cultivating hybrid varieties or high-yielding varieties (HYV) significantly improves diet diversity. Conversely, cultivating the local variety decreases household dietary diversity. Hence, any type of variety that is not local has a positive impact on the dietary diversity of the household. The positive effect of HYV crops supports previous evidence arguing that flood-irrigated fields are more fertile and thus can provide support to HYV of crops (Banerjee, 2010; Rasid and Paul, 1987); and that the main adaptation strategies of farmers are conversion to fish production and use of different crop varieties in alternate years (Maya et al., 2019). The food security of households hit by floods is also improved by wealth (which is increasingly positive with respect to its level), area of land owned (Ehsan and Akter, 2020), remittances received (Petrova, 2021), education, the presence of the mother-in-law, and livestock (Harris-Fry et al., 2017; Sraboni et al., 2014); and decreases if the household experiences the death of the main income earner (Islam and Sharma, 2021).

The individual effects of floods on nutrition generally confirm the household-level estimates. However, the estimated results are less significant because nutritional outcomes tend to require more time to materialize (Evans et al., 2019; Alemayehu Azeze and Huang, 2014). The negative effect of income accumulation in the agricultural sector, the loss of income due to the illness of a member, the use of plots for agricultural activities, and the increasingly positive role of wealth and assistance are confirmed by individual estimations.

1.4.2 Gender-mediated effects of floods on FNS

In this section, I discuss the results of the estimation of Model 2 (Table 1.4, full models in Table A11-A12) through which I are able to detect any gender-related differential effect on household food security and on nutrition, due to the gender of the household head and the gender of the individual household members, respectively. Next, I aim at uncovering any gender differential effect on household food security and nutrition, that is related to the gender of the household's crop-owner (Model 3) (Table 1.5, full models in Table A13-A14). Building on existing evidence showing the importance of land ownership as a determinant of household's food allocation (Harris-Fry et al., 2017), I follow Asfaw and Maggio (2018)'s approach and apply it to the food security and nutritional status in the context of floods, in relation to the gender of household's land owner. Since I am using a fully-interacted model, the estimated coefficients should be interpreted as the relative difference from the baseline category, indicated by the interaction term. For example, if the interaction term is a binary variable =0 if male and =1 if female, and if the coefficient for females is negative and significant, it means that the female's coefficient is

Table 1.3: Direct effect of floods on FNS: : Household/individual level

VARIABLES	(1) FCS	(2) HDDS	(3) HHS	(4) BMI
Flood immediate	-4.05**	-1.29***	0.24***	-0.55***
	(1.71)	(0.18)	(0.07)	(0.10)
Flood delayed	10.44***	2.69***	-0.21***	0.29***
	(1.60)	(0.17)	(0.06)	(0.11)
Share agri-workers	-4.57***	-1.02***	0.06*	-0.28***
	(0.84)	(0.09)	(0.03)	(0.06)
Wealth quintile=5	7.68***	0.71***	-0.05*	0.20***
	(0.97)	(0.10)	(0.03)	(0.06)
Cash assistance	347.40***	77.14***	-3.54***	16.48***
	(26.46)	(2.60)	(0.91)	(2.14)
Self-sufficient rice	1.70***	0.24***	-0.07***	-0.03
	(0.48)	(0.05)	(0.01)	(0.03)
Plot use: non-agriculture	1.71***	0.18***	-0.01	-0.06**
	(0.46)	(0.04)	(0.01)	(0.03)
Crop type: local variety	-0.84	-0.10*	-0.01	-0.02
	(0.54)	(0.06)	(0.01)	(0.03)
Crop type: HYV	0.74	0.11*	-0.01	-0.01
	(0.65)	(0.07)	(0.02)	(0.04)
Other controls	Yes	Yes	Yes	Yes
Observations	13,758	13,758	13,758	42,835
R-squared	0.17	0.33	0.02	0.41

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1
Note: Columns (1)-(3) report results at the household-level,
Column (4) reports results at the individual-level.

significantly more negative compared to male's coefficient.

Starting from the gender-mediated effects related to headship, I obtain that female-headed households are negatively impacted by floods in terms of dietary diversity and nutrition, stronger than male-headed households. In fact, Bangladeshi male household heads have the highest dietary diversity, whereas women eat more low-status foods and have lower dietary adequacy. This result is in line also with Flatø et al. (2017) and Tanny and Rahman (2017) who argue that Bangladeshi women present vulnerabilities with respect to men towards food security, especially in contexts where the impact of weather shocks are mediated by socially constructed gender roles, land ownership differentials and gender-power asymmetries.

In terms of land-ownership, our results indicate that female full or partial ownership of land strengthens the negative effects of flood on food and nutrition security. This finding confirms evidence by Asfaw and Maggio (2018) who find similar results in the context of Malawian household affected by drought. Our finding also reinforces existing evidence on the severe

Table 1.4: Impact of floods on FNS: Female (vs. Male) Household Head and Member

	Female Head			Female Member
VARIABLES	(1) FCS	(2) HDDS	(3) HHS	(4) BMI
Flood immediate	-3.65	-1.68***	-0.02	-0.48***
	(4.22)	(0.43)	(0.29)	(0.13)
Flood delayed	6.56**	2.71***	-0.10	0.40***
	(3.29)	(0.40)	(0.21)	(0.15)
Share agri-workers	-4.40***	-0.50**	0.10	-0.27***
	(1.71)	(0.21)	(0.09)	(0.08)
Mother in-law	3.93**	0.65***	-0.07*	0.09
	(1.74)	(0.16)	(0.04)	(0.07)
Wealth (quintile=5)	5.02***	0.56***	-0.07	0.25***
	(1.74)	(0.17)	(0.07)	(0.09)
Plot size	0.02***	0.00***	-0.00	0.00
	(0.01)	(0.00)	(0.00)	(0.00)
Cash assistance	415.56***	85.11***	-8.04***	18.61***
	(54.46)	(5.71)	(2.43)	(3.00)
Self-sufficient rice	1.11	0.13	-0.04	-0.03
	(1.16)	(0.11)	(0.04)	(0.04)
Plot use: non-agriculture	2.81***	0.17*	-0.01	-0.04
	(0.99)	(0.10)	(0.03)	(0.04)
Other controls	Yes	Yes	Yes	Yes
Observations	13,758	13,758	13,758	42,835
R-squared	0.18	0.34	0.02	0.42

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1
Note: Columns (1)-(3) report results for female heads at the household-level, Column (4) reports results for female members at the individual-level.

consequences of weather shocks on households where women are responsible of the land[8], especially in terms of food security depletion.

The main factors positively affecting food security for households with female heads and female land-owners are cash assistance, income diversification, land area owned, wealth and receiving remittances. These findings support existing evidence suggesting that reducing the gender gap through income diversification would benefit household dietary diversity and food security (Islam et al., 2018). Factors disadvantaging households with female heads and female crop-owners are male-migration, rice self-production, cultivation of non-local crop varieties, use of crops for fisheries and marital shock.

Zooming-in these factors, I discuss the mechanisms behind the impacts of the floods.Cash assistance improves FNS independently on the gender of the member, of the head of the house-

[8]In our sample, around 13% of crop-owners are female household-heads (70% are male household-heads, 17% are owned jointly/mixed)

Table 1.5: Impact of floods on FNS: Female (vs. others) Land Owner

	Female Land Owner			
VARIABLES	(1) FCS	(2) HDDS	(3) HHS	(4) BMI
Flood immediate	-14.30**	-3.69***	0.47	-1.29***
	(5.70)	(0.57)	(0.36)	(0.41)
Flood delayed	13.96***	4.28***	-0.18	1.00**
	(4.79)	(0.56)	(0.30)	(0.39)
Share agri-workers	-3.26*	-0.34	0.15	-0.29
	(1.93)	(0.23)	(0.09)	(0.18)
Mother in-law	5.65***	0.71***	-0.10	0.31**
	(1.78)	(0.18)	(0.06)	(0.15)
Migrant	-2.20**	0.01	0.04	-0.24***
	(1.01)	(0.11)	(0.04)	(0.08)
Cash assistance	333.75***	78.06***	-7.77**	16.34**
	(63.72)	(7.28)	(3.28)	(8.01)
Self-sufficient rice	-0.18	0.15	-0.09*	0.22*
	(1.36)	(0.14)	(0.05)	(0.12)
Plot use: non-agriculture	3.31***	0.23*	-0.09**	-0.02
	(1.27)	(0.13)	(0.05)	(0.11)
Crop type: local variety	-0.54	-0.02	-0.08	0.17
	(1.95)	(0.21)	(0.06)	(0.15)
Other controls	Yes	Yes	Yes	Yes
Observations	13,758	13,758	13,758	42,835
R-squared	0.17	0.31	0.03	0.33

Robust standard errors in parentheses: *** $p<0.01$, ** $p<0.05$, * $p<0.1$
Note: Columns (1)-(3) report results at the household-level, Column (4) reports results at the individual-level.

hold and the land owner. However, female crop-owners are more strongly positively affected, compared to males. This may be explained by the fact that, when woman have access to cash and are able to make decisions (being the housheold head or land owner), they prioritize the food consumption and nutrition of their household. This explanation is supported by our individual-level results which show an increase in adult BMI and child nutrition, for female headed-households. Household assets (measured by the wealth index) systematically increase food and nutritional outcomes, as the level of wealth increases. In Bangladesh, various assistance programs specifically target women to enhance their food security and nutrition, especially in the aftermath of natural disasters such as floods. These programs often provide cash assistance, which empowers women by giving them greater control over household resources. The increased financial autonomy allows women to make critical decisions regarding food purchases and nutrition for their families. Studies have shown that households headed by women or where women own land are more likely to recover from flood shocks in the long run, largely

due to the support from these targeted assistance programs. The cash assistance not only helps in immediate recovery but also contributes to long-term resilience by improving women's economic stability and their ability to secure nutritious food for their families (Ahmed et al., 2014; Ali et al., 2023; Hossain et al., 2021).
Studies have shown that households headed by women or where women own land in Bangladesh are more likely to recover from flood shocks in the long run, largely due to the support from targeted assistance programs. For example, cash assistance programs provided before anticipated severe floods have been effective in helping these households mitigate flood impacts and recover more swiftly (Gros et al., 2023). Research also highlights that female-headed households, when given priority in recovery programs, demonstrate significant resilience and better recovery outcomes (UNDP, 2022). Additionally, private transfers and social safety nets targeting female-headed households have been critical in enhancing their capacity to cope with and recover from natural disasters, including floods (MOZUMDER et al., 2009).

The level of household's wealth is indeed recognized as a significant determinant of adult nutritional status (Sraboni et al., 2014) which attenuates the negative impact of weather shocks, as a cushion (Marchetta et al., 2021). Although the effect of wealth is generally increasingly positive, it is slightly weaker for female than for male headed-households. Other positive effects on food security are given by age, plot size and education of household head. Although the age and size of the plot do not seem to have differential impacts based on the head's gender, education does. The education of male heads has a strong positive impact on food consumption, instead the education of females improves the level of acute hunger (HHS). In both cases, the diversity of the diet is improved by a higher level of education. Overall, indeed, education, wealth and occupation are important determinants of intra-household distribution of resources and food allocation (Harris-Fry et al., 2017).

Being self-sufficient on rice strongly positively affects food security only for male headed households. In fact, the percentage of rice consumption coming from own production of households headed by males is twice as much as the percentage of household headed by females (respectively 43% and 22%, respectively). The importance of rice own-production is very high in the aftermaths of a disruptive weather shock. As a result of the shock, the prices of goods increases, including the price of the staple food rice, therefore producing it for own consumption is the best coping strategy to ensure food availability and consumption for the household Ansah et al. (2021).

The dietary diversity of male-headed households is positively correlated to the use of household plots for fisheries, but this effect doas not persist for female-headed household. Males are usually more expert on fishing, as they generally participate more in fishing activities (Kleiber et al., 2015). Therefore, households led by males are more prone to benefit from this activity in terms of food security. The use of plots for non-agricultural activities has positive differential effects for women: it seems to benefit more the food security and adult nutrition in households led by women, or household where a woman owns the land. The latter case also improves the nutrition of children residing in households.

The FNS is also impacted by the type of crop variety cultivated by the household. The cultivation of the local crop variety has negative effects on male-headed households' food security, while he cultivation of hybrid crop varieties has positive effect. This is probably because, when exposed to agriculture extensions and training, farmers are more inclined on choosing the appropriate mechanisms. However, since mainly men participate in these activities (Mehar et al., 2016) and to informal networks, which are important factors in shaping women's participation in agricultural technology choice and decisions (Mutenje et al., 2016), women remain disadvantaged. Therefore, women having little access to resources, technology and social networks - especially in the context of Bangladesh - often lack the necessary knowledge to cultivate crops that are different from the traditional varieties.

The migration of a household member has an opposite and differential effect for male and female heads and also for female and male crop-owners. This effect is positive for households with a male head or crop-owner and negative for households with a female head or crop-owner. Household members, mostly males, usually migrate looking for employment opportunities leaving their family behind (Nellemann et al., 2011). This often results in a feminization of responsibilities, which adds pressure on women who may become overburdened with household responsibilities (Owusu et al., 2019; De Pinto et al., 2020; Naz and Saqib, 2021). This intensification of women's workload accentuates pre-existing difficulties in accessing resources, particularly food and water (Eastin, 2018), exacerbating the negative effects of floods on women FNS.

Lastly, marital status plays an important role in determining the level of food consumption, dietary diversity, hunger, and overall nutrition. Our data suggests that households headed by females who are married, have higher food security and nutritional status (Table A15). The comparison of FNS between married and not married male-headed households, instead, does not present significant differences. Additionally, I know that only 60% of the women who lead households in our sample are married, while 97% of the men in male-lead households are married (Table A16). Our findings support existing evidence on the importance of marital status in determining the reason why female headed households are poorer than male headed households, which is true in general, except when the female head is married (Brown and van de Walle, 2021). I add on this finding by providing evidence that households who are led by a married female, are more food secure than households who are led by an unmarried female. Indeed, our results suggest that households led by a female who is married have approximately the same FNS of the households led by a married male. On the contrary, households led by an unmarried female, present lower food consumption, dietary diversity, and higher hunger score, than those households that are headed by an unmarried male. Indeed, existing evidence shows that single-headed households are found to be more vulnerable to climate variability than households headed by two adults (Flatø et al., 2017). Although this previous evidence does not differentiate between gender of household head, it confirms our findings that unmarried females are disadvantaged with respect to married ones.

Looking at the gender differentials in crop-ownership, I find that households where the crops are owned by females are less food secure, overall (Tables A11-A12). As for the household head, I find that marital status is an important mechanisms explaining the gender differentials in food security. In fact, households where crops are owner by married female have higher food consumption and a lower hunger compared to those with non-married FLO. For households whose crops are owned by males or jointly, the marital status seems to play a significant role only in terms of the hunger score, which is higher if the owner is not married. I find disparities in gender related to the marital status, of both the household head and the crop-owners. Households with a female head present higher food security if married. This could be explained by the fact that oftentimes the households headed by females are created due to a marital shock i.e. death of husband or divorce. Since usually the husband is the main figure in the households with an income and food-earning livelihood, when the marital shock happens, the resulting unmarried female-headed household may be very much worse-off in terms of well-being (Brown and van de Walle, 2021). This is reflected by the negative coefficient of the variable capturing the death of main earner (Table A11).

Another reason why married FHH are better off may be that they receive remittances from the husband who has migrated. This is reflected by the positive effect of remittances on the hunger score. However, the migration of the husband could also have negative repercussions on the food consumption of the household, especially when the female is left with the management of household's crops. When females have additional burden of operating the crops (in addition to their usual household tasks), it can negatively affect the well-being of the household, especially in the aftermaths of a flooding (Table A13, column 1). As a matter of fact, the vast majority of the households with female crop-owners are also headed by female (82%) and only half of these are married. This evidence reinforces previous findings and expands on the importance of marital status when analyzing intra-household well-being disparities.

1.4.3 Additional Results

In addition to the primary results, further analyses were conducted to explore the dynamic and non-linear impacts of flooding on food security and nutrition outcomes using interaction, quadratic, and 'alternative times' models. These additional models were developed to provide a more nuanced understanding of the relationship between flood exposure and FNS outcomes, and to assess gender-differentiated impacts over time.

The interaction model examines how the occurrence of both immediate and delayed floods affects food consumption (FCS), dietary diversity (HDDS), household hunger (HHS) and nutrition (BMI) while controlling for the interaction between different time periods of flood exposure. Consistent with the literature, this model demonstrates that while floods may initially enhance food security through external aid or recovery mechanisms, the combination of repeated or prolonged exposure tends to reverse these benefits, as documented by studies such as Skoufias et al. (2011) and Carter et al. (2007).

The quadratic model introduces non-linearities to capture diminishing returns from extended flood exposure. This aligns with research indicating that while initial flood recovery can improve food security, over time, the ability of households to maintain these gains diminishes as resources become exhausted (Carter et al., 2007). In particular, I find that while delayed floods have a positive effect on FCS and HDDS, the squared terms highlight a significant decrease in these benefits as flood exposure persists, corroborating studies on the limitations of prolonged disaster recovery (Alderman et al., 2006).

how floods during "normal times" (July 1-14 in the years 2013, 2014, 2017, 2018)9 impact food security outcomes.

The 'alternative times' model assesses the effects of flood exposure at different time intervals, specifically during 'normal times' outside the monsoon season (July 1-14 in the years 2013, 2014, 2017, 2018), to account for the time sensitivity of the impact on households. This model shows that immediate floods can positively affect dietary diversity (HDDS) in the short term, while delayed floods have more significant positive long-term effects on food and nutrition security. These findings confirm the robustness of the main results and highlight that flood timing is crucial in determining its impact on food and nutrition security.

Gender-differentiated results in all models emphasize the distinct challenges faced by female-headed households, female members and households with female landowners. The analyses reveal that female-headed households tend to experience greater positive impacts on FCS and HDDS in the long run but are more vulnerable to the adverse effects of repeated flood exposure. This is consistent with the literature, which underscores the heightened vulnerability of women in disaster contexts due to structural inequalities in resource access (Neumayer and Plümper, 2007; Quisumbing, 2013). Similarly, female landowners, while benefiting more from delayed floods in terms of food security, face significant challenges when exposed to multiple floods, reflecting their difficulty in accessing post-disaster support (Quisumbing et al., 2018).

These supplementary findings reinforce the robustness of the conclusions drawn from the fixed effects linear models and further illuminate the complex dynamics at play in flood-prone rural areas. The detailed tables and model specifications for the interaction, quadratic, and alternative times models can be found in the Appendix (Tables A20-A28), where readers can explore the full scope of these additional analyses.

1.5 Conclusions

This paper contributes to the literature by analysing short- and long-run gendered effects of flood severity on the household food security and individual nutrition in rural Bangladesh, which has received little attention. I start by estimating the overall impact of floods on FNS, in terms of household food consumption, dietary diversity and hunger, and in terms of household members' nutrition. Then, I deepen our insights by disentangling the effects by the gender of household head, member and land owner.

The results suggest that floods impact FNS differently in the short and long-run. Tn the short-run, floods decrease food security and nutritional outcomes, in line with our expectations and with previous research (Ansah et al., 2021; d'Errico et al., 2019; Demeke et al., 2011). Instead, the long-run effects show that when rural households are inundated multiple times, they are able to adapt and recover. This is due to various reasons. Households may develop a recovering capacity after being inundated various times (Vitellozzi and Giannelli, 2023), through aid received in the forms of cash assistance - which indeed was 25% higher for households residing in areas repeatedly flooded compared to those who were not; and by implementing strategies such as income diversification; sending members away and receiving remittances (Giannelli and Canessa, 2021). Another reason why the floods may have a positive effect in the long-run is that flood-irrigated fields are more fertile and can provide support to high-yielding varieties (HYV) and hybrid varieties of crops (Rasid and Paul, 1987). This happens when the severity of the flood is not high and is reflected by the positive effects of these crop varieties on household food security and nutrition, in the results. The results emphasize the role of monsoon riverine floods as a threat to food and nutrition security but also as an important source of irrigation in Bangladesh. In the absence of widespread state-led irrigational reforms in Bangladesh, fresh-water floods supplement private irrigation (including groundwater irrigation) for the majority of poor peasants living in the country (Banerjee, 2010).

I also observe gender-mediated effects, through an heterogeneity analysis by the gender of the household head, of the members and of household's land-owner. The short-term results show that female-headed households and female members are negatively impacted by floods in terms of dietary diversity and nutrition, stronger than male-headed households. Female full or partial ownership of land exacerbates the negative effects of flood on food and nutrition security. These results support existing evidence that Bangladeshi women present vulnerabilities with respect to men towards food security in the context of weather shocks(Flatø et al., 2017; Tanny and Rahman, 2017). Households face severe consequences of these adverse shocks when women are the only responsible of the land, through a reduction of household food consumption and dietary diversity (Asfaw and Maggio, 2018). Furthermore, the alleged long-run recover mechanism seems to be channeled through females (members, headship and land-ownership). Although women are more vulnerable than men to weather shocks, they seem to be the ones who are able to better recover from the flood shock over time. I therefore find evidence of a "mismatch" between vulnerability and recovery from the shock: women seem to develop a resilience capacity after being inundated multiple times, which translates into improved household food security and adult nutrition.

I identify some factors that could improve food security for female heads and crop-owners: cash assistance, income diversification, land area owned, wealth, remittances received and the use the plot for non-agricultural activities. These factors contribute to reducing the FNS gender-gap for rural household affected by floods, by benefiting household dietary diversity and food security (Islam et al., 2018).

In addition to the primary findings, further analyses presented in the Appendix (Tables A20-A28) provide deeper insights into the complex dynamics of flood impacts on food security and nutrition in rural Bangladesh. The interaction, quadratic, and alternative times models extend the core analysis by accounting for non-linear effects, gender disparities, and alternative timing of flood exposure. These additional results reveal that while delayed floods generally improve food security and dietary diversity, repeated flood exposure erodes these gains over time, which is consistent with the findings of Carter et al. (2007) and Skoufias et al. (2011) on the diminishing returns from prolonged disasters. Furthermore, the gender-differentiated findings underscore the unique vulnerabilities of female-headed households and female landowners, particularly when exposed to multiple floods. This aligns with research by Quisumbing et al. (2018) and Neumayer and Plümper (2007), who highlight the structural challenges women face in recovering from disasters, including limited access to resources and support. These findings reinforce the importance of incorporating gender-sensitive strategies in disaster recovery interventions to ensure equitable and sustained recovery for the most vulnerable populations. These supplementary results enrich the overall understanding of the long-term effects of floods on rural households and provide critical insights for policymakers aiming to address the multifaceted impacts of natural disasters on food security and nutrition. (Quisumbing et al., 2018).

A word of caution is in order regarding the results from this paper. This study still has limitations, which I believe offer opportunities for future research. First, due to data limitations, the impact of weather shocks on food and nutrition security still has a large research potential. In the future, other types of weather shocks could be added to the analysis. For instance, the population might have been affected by other weather events that might have affected the outcomes of interest. Second, weather shocks have both contemporaneous and lagged effects. To take this into account, other empirical strategies might be adopted i.e. the recently developed staggered diff-in-diff methodology (Callaway and Sant'Anna, 2021; De Chaisemartin and D'Haultfoeuille, 2022). Lastly, once the next round of BIHS data will be available, further research can incorporate it in the analysis to study the effects of recent disruptive floods that hit Bangladesh during the 2022 and 2023 monsoon season. The use of longer-term panel data would be useful to see whether there are short-term or long-term patterns in the allocation of resources or livelihood strategies of rural households in response to weather shocks, and the relative impact on food security and nutrition.

In a disaster scenario, it is important to understand how households and household members are affected – how their activities, roles and decision-making power influences their well-being – to have a broader understanding of the mechanisms driving the effects of weather shocks. In a context as Bangladesh, it seems crucial to address such problems under a gender perspective, to improve women's and households' responses to weather shocks, to secure fair intra-household resource distribution and to implement more effective disaster-relief interventions (Chen et al., 2021).

Some policy interventions that could help improve gender-differentials of food security in flood-context are to incentivize crop and income diversification which seem to be effective mechanisms adopted by households to cope with the floodings and FNS outcomes. Additionally, since the results indicate that the area of land owned is a positive factor for female-led households' well-being, a plausibly optimal policy intervention would be to improve property and land right towards women. Other interventions to foster females' well-being in female headed-households or female-owned crops, would be to decease the burden of migration on women. For example, by reducing mobility barriers, or by incentivizing the redistribution of tasks within the households after the migration. Lasly, the significantly more positive effects of cash assistance in female-led households, indicate that when females receive cash assistance, they make good use of it. Therefore, a useful intervention could be to provide women with cash assistance, together with interventions aimed at improving female access to credit, and femal decision-making power within the household.

Our study underscores the notion that climate policies at the local level should be gender-sensitive. The ability to recover from the floods, and the mechanisms through which the severity of shocks affects female heads and crop-owners, differ from their male counterparts. Therefore, policies should aim at promoting access to credit, subsidies, assistance, access to land and income-earning activities, especially for female-headed households. These interventions could be beneficial for the increase of female adaptation and recovery to weather shocks. I hope that, through time, the suggested policies can help eradicate social and gender norms disadvantaging women, which are still present in the Bangladeshi culture. It is therefore of paramount importance to implement targeted interventions to contribute to a positive change in the well-being of vulnerable groups and decrease gender disparities.

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Appendix

Table A1: Sample of analysis

Round	#households	#individuals
1	4586	18875
2	4586	21582
3	4586	24332
Total	13758	64789

Table A2: Descriptive statistics of main variables – Round 1

Variable	Level	N	Mean	SD	Min	Max
Female hh-head	Household	4586	0.18	0.38	0.00	1.00
Gender female	Individual	18875	0.53	0.50	0.00	1.00
Age (in years)	Individual	18875	26.17	19.72	0.00	120.00
Share of hh members working in agricultural sector	Household	4586	0.28	0.25	0.00	1.00
Dependency ratio	Household	4586	0.40	0.22	0.00	1.00
Wealth index (household durable assets & agricultural assets)	Household	4586	0.18	0.11	0.00	0.88
TLU (Tropical Livestock Units)	Household	4586	0.63	1.00	0.00	30.45
Soil type: clay	Household	4586	0.14	0.35	0.00	1.00
Soil type: loam	Household	4586	0.25	0.43	0.00	1.00
Soil type: sandy	Household	4586	0.17	0.38	0.00	1.00
Soil type: clay-loam	Household	4586	0.52	0.50	0.00	1.00
Soil type: sandy-loam	Household	4586	0.29	0.45	0.00	1.00
Number of different crops cultivated by the hh	Household	4586	1.56	1.94	0.00	15.00
Number of crops total cultivated by the hh	Household	4586	3.48	5.71	0.00	70.00
Shock: Death of main earner	Household	4586	0.02	0.13	0.00	1.00
Shock: Income loss due to illness or injury of hh member	Household	4586	0.04	0.19	0.00	1.00
Total areal of land owned by the hh in the last 12 months	Household	4586	88.14	141.81	0.25	2412.0
Amount (kg) pc of food grain storage: paddy, rice, wheat	Household	4586	60.78	177.53	0.00	3861.0
Migrant =1 if anyone, who was a members of hh in the past 5 years, is currently a migrant (living away for 6 months or more) within the country (but not in same upazilla) or abroad	Household	4586	0.22	0.41	0.00	1.00

Remittance received by the household in the last 12 months (PPP17 district level)	Household	4586	0.89	3.22	0.00	104.25
Cash assistance per capita from any SSN program, received by hh in last 12 months (PPP17 district level)	Household	4586	1.06	2.47	0.07	37.88
Total amount pc currently saved by hh (PPP17)	Household	4586	0.21	0.89	0.00	24.25
Share of rice hh consumption that comes from own production, in the last 7 days	Household	4586	0.37	0.48	0.00	1.00
=1 if household used at least one plot for agriculture	Household	4586	0.61	0.49	0.00	1.00
=1 if household used at least one plot for fisheries	Household	4586	0.16	0.37	0.00	1.00
=1 if household used at least one plot for homestead	Household	4586	1.00	0.00	1.00	1.00
=1 if household used at least one plot for non-agriculture	Household	4586	0.16	0.36	0.00	1.00
=1 if household cultivates at least one crop with local variety	Household	4586	0.26	0.44	0.00	1.00
=1 if household cultivates at least one crop with high yield variety (HYV)	Household	4586	0.45	0.50	0.00	1.00
=1 if household cultivates at least one crop with hybrid variety	Household	4586	0.06	0.24	0.00	1.00
Division where household is located	Household	4586	3.79	1.81	1.00	7.00
Month of interview	Household	4586	5.40	5.03	1.00	12.00

Table A3: T-test Attrition Sample vs. Final Sample: Comparison of Key Characteristics at Baseline

Variable	Final	Attrition	Mean F	Mean A	Diff.	Std. Err.	t-val.	p-val.
Female head	4586	1917	0.180	0.170	0.011	0.011	1.00	0.312
Age head	4586	1917	43.535	45.693	-2.158	0.380	-5.70	0.000
Crop Variety	4586	1917	1.576	1.605	-0.030	0.054	-0.55	0.584
Wealth Index	4586	1917	0.184	0.186	-0.002	0.003	-0.70	0.499
TLU	4586	1917	0.632	0.682	-0.051	0.028	-1.85	0.063
Self-Sufficiency Ratio	4586	1917	0.370	0.334	0.036	0.013	2.80	0.005
Soil Type (Clay)	4586	1917	0.140	0.154	-0.015	0.009	-1.55	0.126
Soil Type (Loam)	4586	1917	0.253	0.280	-0.027	0.012	-2.25	0.025
Soil Type (Sandy)	4586	1917	0.173	0.207	-0.034	0.011	-3.20	0.002
Soil Type (Clay Loam)	4586	1917	0.519	0.512	0.007	0.013	0.50	0.606
Soil Type (Sandy Loam)	4586	1917	0.292	0.286	0.007	0.013	0.55	0.591
Education head	4586	1917	2.725	2.687	0.038	0.035	1.10	0.263
Cash Assistance (Tk)	4586	1917	668.888	669.736	-0.850	54.678	0.00	0.988
Rice Assistance (Kg)	4586	1917	4.280	5.899	-1.619	0.782	-2.05	0.038
Rice Assistance (food Tk)	4586	1917	2.292	2.791	-0.498	0.322	-1.55	0.121
Cash Assistance (food Tk)	4586	1917	16.383	21.836	-5.454	10.854	-0.50	0.616
Land Use (Agricultural)	4586	1917	0.608	0.626	-0.018	0.013	-1.35	0.173
Land Use (Fisheries)	4586	1917	0.164	0.171	-0.007	0.010	-0.65	0.528
Land Use (Homestead)	4586	1917	1.000	0.997	0.003	0.001	3.80	0.000
Land Use (Non-Agri.)	4586	1917	0.158	0.183	-0.026	0.010	-2.55	0.011
Crop Type (Local Var.)	4586	1917	0.259	0.310	-0.052	0.012	-4.30	0.000
Crop Type (HYV)	4586	1917	0.452	0.443	0.010	0.013	0.75	0.465
Crop Type (Hybrid)	4586	1917	0.063	0.089	-0.027	0.007	-3.85	0.000

Table A3 indicates weather the dropped observations are different from the sample of analysis on some main indicators. The households in the attrition sample appear to be 2 years older, own slightly more livestock, are less self-sufficient on rice, own more soil types loam and sandy, received more rice assistance (kg), and cultivate more local and hybrid varieties of crop types, compared to the households in the main sample. These differing characteristics are included in the analysis as control variables, to account for and mitigate potential biases introduced by differences between the samples, improving the robustness of the results.

Table A4: Descriptive statistics of main variables – Round 2

Variable	Level	N	Mean	SD	Min	Max
Female hh-head	Household	4586	0.19	0.40	0.00	1.00
Gender female	Individual	21582	0.53	0.50	0.00	1.00
Age (in years)	Individual	21582	27.73	20.25	0.00	123.00
Share of hh members working in agricultural sector	Household	4586	0.24	0.21	0.00	1.00
Dependency ratio	Household	4586	0.37	0.21	0.00	1.00
Wealth index (durable assets & agricultural assets)	Household	4586	0.17	0.10	0.01	0.91
TLU (Tropical Livestock Units)	Household	4586	0.66	1.07	0.00	25.40
Soil type: clay	Household	4586	0.13	0.34	0.00	1.00
Soil type: loam	Household	4586	0.25	0.44	0.00	1.00
Soil type: sandy	Household	4586	0.17	0.37	0.00	1.00
Soil type: clay-loam	Household	4586	0.55	0.50	0.00	1.00
Soil type: sandy-loam	Household	4586	0.30	0.46	0.00	1.00
Number of different crops cultivated by the hh	Household	4586	1.79	1.31	1.00	12.00
Number of crops total cultivated by the hh	Household	4586	2.99	4.92	0.00	63.00
Shock: Death of main earner	Household	4586	0.02	0.13	0.00	1.00
Shock: Income loss due to illness or injury of hh member	Household	4586	0.04	0.20	0.00	1.00
Total areal of land owned by the hh in the last 12 months	Household	4586	94.37	157.10	0.00	3092.00
Amount (kg) pc of food grain storage: paddy, rice, wheat	Household	4586	69.12	181.59	0.00	3487.75
Migrant =1 if anyone, who was a members of hh in the past 5 years, is currently a migrant (living away for 6 months or more) within the country (but not in same upazilla) or abroad	Household	4586	0.08	0.28	0.00	1.00

Remittance received by hh in last 12 months (PPP17)	Household	4586	1.28	4.38	0.00	162.44
Cash assistance per capita from any SSN program, received by hh in last 12 months (PPP17 district level)	Household	4586	0.01	0.00	0.00	0.03
Kg of rice assistance pc from any SSN program, received by hh in last 12 months	Household	4586	0.71	0.83	0.00	8.30
Total amount pc currently saved by hh (PPP17)	Household	4586	0.22	0.87	0.00	28.48
Share of rice hh consumption that comes from own production, in the last 7 days	Household	4586	0.36	0.48	0.00	1.00
=1 if household used at least one plot for agriculture	Household	4586	0.50	0.50	0.00	1.00
=1 if household used at least one plot for fisheries	Household	4586	0.16	0.37	0.00	1.00
=1 if household used at least one plot for homestead	Household	4586	0.99	0.10	0.00	1.00
=1 if household used at least one plot for non-agriculture	Household	4586	0.43	0.49	0.00	1.00
=1 if household cultivates at least one crop with local variety	Household	4586	0.22	0.41	0.00	1.00
=1 if household cultivates at least one crop with high yield variety (HYV)	Household	4586	0.45	0.50	0.00	1.00
=1 if household cultivates at least one crop with hybrid variety	Household	4586	0.08	0.27	0.00	1.00
Division where household is located	Household	4586	3.79	1.81	1.00	7.00
Month of interview	Household	4586	3.73	1.16	1.00	9.00

Table A5: Descriptive statistics of main variables – Round 3

Variable	Level	N	Mean	SD	Min	Max
Female hh-head	Household	4586	0.21	0.41	0.00	1.00
Gender female	Individual	24329	0.53	0.50	0.00	1.00
Age (in years)	Individual	24329	29.22	20.73	0.00	127.00
Share of hh members working in agricultural sector	Household	4586	0.15	0.16	0.00	1.00
Dependency ratio	Household	4586	0.36	0.21	0.00	1.00
Wealth index (household durable assets & agricultural assets)	Household	4586	0.19	0.10	0.00	1.00
TLU (Tropical Livestock Units)	Household	4586	0.73	1.25	0.00	30.50
Soil type: clay	Household	4586	0.16	0.36	0.00	1.00
Soil type: loam	Household	4586	0.25	0.43	0.00	1.00
Soil type: sandy	Household	4586	0.16	0.37	0.00	1.00
Soil type: clay-loam	Household	4586	0.61	0.49	0.00	1.00
Soil type: sandy-loam	Household	4586	0.31	0.46	0.00	1.00
Number of different crops cultivated by the hh	Household	4586	1.74	1.24	1.00	15.00
Number of crops total cultivated by the hh	Household	4586	2.77	4.36	0.00	62.00
Shock: Death of main earner	Household	4586	0.02	0.14	0.00	1.00
Shock: Income loss due to illness or injury of hh member	Household	4586	0.04	0.19	0.00	1.00
Total areal of land owned by the hh in the last 12 months	Household	4586	92.43	135.69	0.50	1911.50
Amount (kg) pc of food grain storage: paddy, rice, wheat	Household	4586	58.63	150.80	0.00	3720.86
Migrant =1 if anyone, who was a members of hh in the past 5 years, is currently a migrant (living away for 6 months or more) within the country (but not in same upazilla) or abroad	Household	4586	0.25	0.43	0.00	1.00

Remittance received by hh in last 12 months (PPP17)	Household	4586	1.33	3.77	0.00	117.68
Cash assistance per capita from any SSN program, received by hh in last 12 months (PPP17 district level)	Household	4586	0.01	0.01	0.00	0.05
Kg of rice assistance pc from any SSN program, received by hh in last 12 months	Household	4586	1.54	3.15	0.00	46.72
Total amount pc currently saved by hh (PPP17)	Household	4586	0.26	1.81	0.00	92.91
Share of rice hh consumption that comes from own production, in the last 7 days	Household	4586	0.41	0.49	0.00	1.00
=1 if household used at least one plot for agriculture	Household	4586	0.54	0.50	0.00	1.00
=1 if household used at least one plot for fisheries	Household	4586	0.15	0.35	0.00	1.00
=1 if household used at least one plot for homestead	Household	4586	0.99	0.09	0.00	1.00
=1 if household used at least one plot for non-agriculture	Household	4586	0.37	0.48	0.00	1.00
=1 if household cultivates at least one crop with local variety	Household	4586	0.15	0.36	0.00	1.00
=1 if household cultivates at least one crop with high yield variety (HYV)	Household	4586	0.48	0.50	0.00	1.00
=1 if household cultivates at least one crop with hybrid variety	Household	4586	0.10	0.30	0.00	1.00
Division where household is located	Household	4586	3.79	1.81	1.00	7.00
Month of interview	Household	4586	3.80	3.17	1.00	12.00

Table A6: Descriptive statistics of FNS variables

Round	Variable	Level	N	Mean	SD	Min	Max
Round 1	Food Consumption Score (FCS)	Household	4586	52.44	17.79	11.50	112.00
	Household Dietary Diversity Score (HDDS)	Household	4586	7.94	1.82	1.00	12.00
	Household Hunger Score (HHS)	Household	4586	0.17	0.62	0.00	6.00
	Body Mass Index (BMI)	Individual	14346	18.31	3.12	9.27	25.00
Round 2	Food Consumption Score (FCS)	Household	4586	62.19	18.68	16.00	112.00
	Household Dietary Diversity Score (HDDS)	Household	4586	9.05	1.62	3.00	12.00
	Household Hunger Score (HHS)	Household	4586	0.18	0.58	0.00	6.00
	Body Mass Index (BMI)	Individual	14412	18.50	3.25	6.67	25.00
Round 3	Food Consumption Score (FCS)	Household	4586	65.64	17.66	24.50	112.00
	Household Dietary Diversity Score (HDDS)	Household	4586	10.37	1.34	5.00	12.00
	Household Hunger Score (HHS)	Household	4586	0.10	0.46	0.00	6.00
	Body Mass Index (BMI)	Individual	14077	19.02	3.20	7.67	25.00

Table A7: Flood Intensity

Flood Year	N (HHs Flooded)	Mean (Intensity)	Std. Dev.	Min	Max
Flood 2013 (Delayed)	1,986	0.094	0.195	0.001	0.985
Flood 2014 (Immediate)	2,841	0.133	0.218	0.001	0.983
Flood 2017 (Delayed)	2,856	0.144	0.219	0.001	0.981
Flood 2018 (Immediate)	1,601	0.114	0.209	0.001	0.982

Table A8: Who owns the household crops?

Owner	Round 1		Round 2		Round 3	
	N.	%	N.	%	N.	%
= 1 all females	709	15.46	475	10.36	600	13.08
= 2 all males	3,385	73.81	3,137	68.40	3,165	69.01
= 3 jointly/mixed	222	4.84	196	4.27	180	3.92
= 0 other	270	5.89	778	16.96	641	13.98
Total	4,586	100.00	4,586	100.00	4,586	100.00

Table A9: Full Regression Model 1 – Household Level

Variables	(1) FCS	(2) HDDS	(3) HHS
Flood immediate	-4.05**	-1.29***	0.24***
	(1.71)	(0.18)	(0.07)
Flood delayed	10.44***	2.69***	-0.21***
	(1.60)	(0.17)	(0.06)
Age	0.67***	0.12***	0.00
	(0.13)	(0.01)	(0.01)
Age^2	-0.01***	-0.00***	-0.00
	(0.00)	(0.00)	(0.00)
Dependency ratio	-0.90	-0.44***	0.05
	(1.07)	(0.12)	(0.04)
N. different crops	0.00	-0.03*	0.00
	(0.20)	(0.02)	(0.00)
Share agri-workers	-4.57***	-1.02***	0.06*
	(0.84)	(0.09)	(0.03)
Mother in-law	3.48***	0.60***	-0.02
	(0.80)	(0.08)	(0.02)
Wealth quintile=2	1.84***	0.23***	-0.05*
	(0.57)	(0.06)	(0.03)
Wealth quintile=3	3.90***	0.43***	-0.08***
	(0.69)	(0.08)	(0.03)
Wealth quintile=4	5.60***	0.54***	-0.08**
	(0.80)	(0.08)	(0.03)
Wealth quintile=5	7.68***	0.71***	-0.05*
	(0.97)	(0.10)	(0.03)
Soil type: clay	0.25	-0.05	0.00
	(0.63)	(0.06)	(0.02)
Soil type: loam	-1.01	-0.03	0.03
	(0.71)	(0.07)	(0.02)
Soil type: sandy	0.33	0.03	-0.02
	(0.76)	(0.08)	(0.02)
Soil type: clay-loam	0.50	0.16**	0.00
	(0.60)	(0.06)	(0.02)
Soil type: sandy-loam	-0.60	-0.03	0.02
	(0.66)	(0.07)	(0.02)
TLU (tropical livestock unit)	1.29***	0.06***	-0.00
	(0.26)	(0.02)	(0.00)
Shock: death main earner	-2.75**	-0.04	0.08*

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Table A9: Full Regression Model 1 – Household Level (continued)

	(1)	(2)	(3)
	(1.13)	(0.12)	(0.05)
Education HH-head	1.32***	0.31***	-0.02
	(0.34)	(0.04)	(0.01)
Plot size	0.01***	0.00	0.00
	(0.00)	(0.00)	(0.00)
Cash assistance (PPP17)	347.40***	77.14***	-3.54***
	(26.46)	(2.60)	(0.91)
Rice assistance (kg)	0.10	0.07***	-0.01**
	(0.09)	(0.01)	(0.00)
Savings (pc PPP17)	0.10	0.01	-0.00
	(0.10)	(0.01)	(0.00)
Remittances (pc PPP17)	0.20	0.00	-0.01***
	(0.24)	(0.02)	(0.00)
Self-sufficient rice	1.70***	0.24***	-0.07***
	(0.48)	(0.05)	(0.01)
Plot use: agriculture	-0.30	0.03	-0.03*
	(0.61)	(0.06)	(0.02)
Plot use: fisheries	0.58	0.17***	-0.02
	(0.63)	(0.06)	(0.02)
Plot use: homestead	-0.84	-0.26	-0.06
	(2.14)	(0.19)	(0.06)
Plot use: non-agriculture	1.71***	0.18***	-0.01
	(0.46)	(0.04)	(0.01)
Crop type: local variety	-0.84	-0.10*	-0.01
	(0.54)	(0.06)	(0.01)
Crop type: HYV	0.74	0.11*	-0.01
	(0.65)	(0.07)	(0.02)
Crop type: hybrid	0.52	0.12*	-0.00
	(0.68)	(0.07)	(0.01)
Constant	25.13***	3.18***	0.32**
	(4.04)	(0.43)	(0.14)
Divisions	Yes	Yes	Yes
Month of interview	Yes	Yes	Yes
Observations	13,758	13,758	13,758
R-squared	0.17	0.33	0.02

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table A10: Full Regression Model 1 – Individual Level

Variables	(1) BMI
Flood immediate	-0.55***
	(0.10)
Flood delayed	0.29***
	(0.11)
Age	0.59***
	(0.01)
Age^2	-0.00***
	(0.00)
Dependency ratio	-0.82***
	(0.08)
N. different crops	-0.01
	(0.01)
Share agri-workers	-0.28***
	(0.06)
Mother in-law	0.06
	(0.05)
Wealth quintile=2	0.02
	(0.04)
Wealth quintile=3	0.09*
	(0.04)
Wealth quintile=4	0.15***
	(0.05)
Wealth quintile=5	0.20***
	(0.06)
Soil type: clay	0.00
	(0.04)
Soil type: loam	-0.00
	(0.04)
Soil type: sandy	-0.05
	(0.05)
Soil type: clay-loam	0.04
	(0.04)
Soil type: sandy-loam	-0.04
	(0.05)
TLU	-0.03***
	(0.01)
Shock: income loss	-0.10**
	(0.05)

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Table A10: **Table A10:** Full Regression Model 1 – Individual Level (Continued)

Variables	BMI
Education HH-head	0.01
	(0.02)
Plot size	0.00
	(0.00)
Cash assistance (PPP17)	16.48***
	(2.14)
Rice assistance (kg)	0.01
	(0.01)
Savings (pc PPP17)	0.01
	(0.01)
Remittances (pc PPP17)	0.01
	(0.02)
Self-sufficient rice	-0.03
	(0.03)
Plot use: agriculture	-0.14***
	(0.04)
Plot use: fisheries	-0.02
	(0.04)
Plot use: homestead	-0.28**
	(0.11)
Plot use: non-agriculture	-0.06**
	(0.03)
Crop type: local variety	-0.02
	(0.03)
Crop type: HYV	-0.01
	(0.04)
Crop type: hybrid	0.01
	(0.04)
Constant	7.66***
	(0.24)
Month of interview	Yes
Division	Yes
Observations	42,835
R-squared	0.41

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table A11: Full regression Model 2 – Gender of Head at Household level

	Male HH-head			Female HH-head		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	FCS	HDDS	HHS	FCS	HDDS	HHS
Flood immediate	-4.23**	-1.22***	0.29***	-3.65	-1.68***	-0.02
	(1.89)	(0.19)	(0.07)	(4.22)	(0.43)	(0.29)
Flood delayed	11.65***	2.70***	-0.24***	6.56**	2.71***	-0.10
	(1.85)	(0.18)	(0.06)	(3.29)	(0.40)	(0.21)
Age	0.59***	0.12***	0.00	0.91***	0.14***	-0.00
	(0.15)	(0.02)	(0.01)	(0.26)	(0.03)	(0.01)
Age^2	-0.00***	-0.00***	-0.00	-0.01***	-0.00***	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Dependency ratio	-0.04	-0.47***	0.03	-1.95	-0.32	0.08
	(1.29)	(0.13)	(0.04)	(1.74)	(0.21)	(0.09)
N. different crops	-0.00	-0.03	0.00	-0.25	-0.09	0.00
	(0.20)	(0.02)	(0.00)	(0.69)	(0.09)	(0.03)
Share agri-workers	-4.61***	-1.09***	0.05	-4.40***	-0.50**	0.10
	(0.98)	(0.10)	(0.04)	(1.71)	(0.21)	(0.09)
Mother in-law	3.22***	0.61***	-0.00	3.93**	0.65***	-0.07*
	(0.86)	(0.09)	(0.02)	(1.74)	(0.16)	(0.04)
Wealth quintile=2	0.00	0.00	0.00	0.85	0.22*	-0.12*
	(0.00)	(0.00)	(0.00)	(1.07)	(0.12)	(0.06)
Wealth quintile=3	2.56***	0.25***	-0.03*	2.75**	0.41***	-0.15**
	(0.58)	(0.06)	(0.02)	(1.31)	(0.14)	(0.07)
Wealth quintile=4	4.38***	0.37***	-0.03	3.59**	0.55***	-0.14**
	(0.72)	(0.07)	(0.02)	(1.45)	(0.16)	(0.06)
Wealth quintile=5	6.55***	0.57***	-0.02	5.02***	0.56***	-0.07
	(0.92)	(0.09)	(0.02)	(1.74)	(0.17)	(0.07)
Soil type: clay	0.52	-0.00	-0.02	-1.14	-0.24*	0.11**
	(0.69)	(0.06)	(0.02)	(1.36)	(0.14)	(0.05)
Soil type: loam	-1.23*	-0.05	0.03	-0.31	0.11	0.07
	(0.74)	(0.08)	(0.02)	(1.53)	(0.15)	(0.06)
Soil type: sandy	0.17	-0.02	-0.02	1.26	0.37**	0.01
	(0.79)	(0.09)	(0.02)	(1.69)	(0.18)	(0.07)
Soil type: clay-loam	0.08	0.10	0.01	2.34*	0.46***	-0.01
	(0.64)	(0.07)	(0.02)	(1.25)	(0.13)	(0.05)
Soil type: sandy-loam	-0.37	-0.07	0.02	-1.84	0.17	0.05
	(0.70)	(0.07)	(0.02)	(1.30)	(0.15)	(0.05)
TLU (tropical livestock unit)	1.31***	0.07***	-0.00	1.14	-0.06	-0.02
	(0.27)	(0.02)	(0.00)	(0.95)	(0.09)	(0.03)

Table A11: (Continued) Full regression Model 2 – Gender of Head at Household level

	Male HH-head			Female HH-head		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	FCS	HDDS	HHS	FCS	HDDS	HHS
Shock: death main earner	-1.85	0.43**	0.04	-2.75**	-0.25	0.10
	(2.30)	(0.21)	(0.06)	(1.32)	(0.15)	(0.07)
Education HH-head	1.52***	0.31***	-0.01	0.83	0.27***	-0.05*
	(0.38)	(0.04)	(0.01)	(0.54)	(0.06)	(0.03)
Plot size	0.01***	0.00	0.00	0.02***	0.00***	-0.00
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Cash assistance (PPP17)	326.32***	74.61***	-2.23**	415.56***	85.11***	-8.04***
	(30.04)	(2.90)	(0.92)	(54.46)	(5.71)	(2.43)
Rice assistance (kg)	0.10	0.07***	-0.01**	0.11	0.08***	-0.01
	(0.10)	(0.01)	(0.00)	(0.15)	(0.02)	(0.01)
Savings (pc PPP17)	0.07	0.01	-0.00	0.07	0.02	-0.00
	(0.14)	(0.01)	(0.00)	(0.11)	(0.01)	(0.00)
Self-sufficient rice	1.86***	0.27***	-0.07***	1.11	0.13	-0.04
	(0.52)	(0.05)	(0.01)	(1.16)	(0.11)	(0.04)
Remittances (pc PPP17)	0.44	-0.01	-0.01	0.14	-0.00	-0.01**
	(0.38)	(0.04)	(0.00)	(0.28)	(0.02)	(0.00)
Plot use: agriculture	-0.14	0.10	-0.03	-0.34	-0.14	-0.05
	(0.70)	(0.07)	(0.02)	(1.24)	(0.13)	(0.04)
Plot use: fisheries	0.63	0.21***	-0.02	0.49	0.06	-0.04
	(0.70)	(0.07)	(0.02)	(1.30)	(0.13)	(0.04)
Plot use: homestead	-0.59	-0.23	0.01	-1.51	-0.23	-0.38
	(2.55)	(0.22)	(0.03)	(3.56)	(0.38)	(0.26)
Plot use: non-agriculture	1.52***	0.17***	-0.02	2.81***	0.17*	-0.01
	(0.50)	(0.05)	(0.01)	(0.99)	(0.10)	(0.03)
Crop type: local variety	-1.08*	-0.12**	-0.01	1.21	0.11	0.01
	(0.57)	(0.06)	(0.01)	(1.63)	(0.19)	(0.05)
Crop type: HYV	0.99	0.10	-0.01	-0.73	0.15	-0.05
	(0.70)	(0.07)	(0.02)	(1.81)	(0.20)	(0.06)
Crop type: hybrid	0.72	0.13*	-0.00	-1.31	-0.04	-0.07
	(0.70)	(0.07)	(0.01)	(2.45)	(0.24)	(0.08)
Divisions	Yes	Yes	Yes	Yes	Yes	Yes
Month of interview	Yes	Yes	Yes	Yes	Yes	Yes

Table A11: (Continued) Full regression Model 2 – Gender of Head at Household level

	Male HH-head			Female HH-head		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	FCS	HDDS	HHS	FCS	HDDS	HHS
Constant	41.46***	3.28***	1.30**	41.46***	3.28***	1.30**
	(8.05)	(0.71)	(0.65)	(8.05)	(0.71)	(0.65)
Observations	13,758	13,758	13,758	13,758	13,758	13,758
R-squared	0.18	0.34	0.02	0.18	0.34	0.02

*Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1*

Table A12: Full regression Model 2 – Gender of Housheold Member Individual level

	Male	Female
Variables	BMI	BMI
Flood immediate	-0.62***	-0.48***
	(0.13)	(0.13)
Flood delayed	0.13	0.40***
	(0.14)	(0.15)
Age	0.54***	0.63***
	(0.01)	(0.01)
Age^2	-0.00***	-0.01***
	(0.00)	(0.00)
Dependency ratio	-0.96***	-0.73***
	(0.11)	(0.11)
N. different crops	-0.03*	-0.00
	(0.01)	(0.02)
Share agri-workers	-0.29***	-0.27***
	(0.08)	(0.08)
Mother in-law	0.01	0.09
	(0.06)	(0.07)
Wealth quintile=2	0.00	0.05
	(0.00)	(0.05)
Wealth quintile=3	0.06	0.14**
	(0.04)	(0.06)
Wealth quintile=4	0.10*	0.23***
	(0.06)	(0.07)
Wealth quintile=5	0.17**	0.25***
	(0.07)	(0.09)
Soil type: clay	0.08	-0.08
	(0.06)	(0.06)
Soil type: loam	-0.04	0.02
	(0.06)	(0.06)
Soil type: sandy	0.06	-0.16**
	(0.06)	(0.07)
Soil type: clay-loam	0.05	0.02
	(0.05)	(0.05)
Soil type: sandy-loam	-0.02	-0.06
	(0.06)	(0.06)
TLU	-0.02	-0.04**
	(0.02)	(0.02)
Shock: income loss	-0.10*	-0.11
	(0.06)	(0.07)

Table A12: Full regression Model 2 – Gender of Housheold Member Individual level (Continued)

	Male	Female
Variables	BMI	BMI
Education HH-head	0.01	0.00
	(0.03)	(0.03)
Plot size	0.00	0.00
	(0.00)	(0.00)
Cash assistance (PPP17)	14.49***	18.61***
	(2.67)	(3.00)
Rice assistance (kg)	0.02***	-0.00
	(0.01)	(0.01)
Savings (pc PPP17)	0.02	-0.00
	(0.01)	(0.01)
Self-sufficient rice	-0.02	-0.03
	(0.04)	(0.04)
Remittances (pc PPP17)	0.02	0.00
	(0.02)	(0.02)
Plot use: agriculture	-0.24***	-0.04
	(0.05)	(0.05)
Plot use: fisheries	-0.02	-0.01
	(0.05)	(0.05)
Plot use: homestead	0.04	-0.61***
	(0.14)	(0.16)
Plot use: non-agriculture	-0.07*	-0.04
	(0.04)	(0.04)
Crop type: local variety	0.01	-0.05
	(0.04)	(0.05)
Crop type: HYV	-0.01	-0.01
	(0.05)	(0.06)
Crop type: hybrid	0.04	-0.00
	(0.05)	(0.06)
Divisions	Yes	Yes
Month of interview	Yes	Yes
Constant	8.12***	8.12***
	(0.41)	(0.41)
Observations	42,835	42,835
R-squared	0.42	0.42

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table A13: Full regression model 3 – Land owner Household level

	Female land owner (FLO)			Male land owner (MLO)			Joint/mixed land owner (JLO)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	FCS	HDDS	HHS	FCS	HDDS	HHS	FCS	HDDS	HHS
Flood immediate	-14.30**	-3.69***	0.47	-3.71*	-1.21***	0.27***	-29.28**	-3.78***	0.38
	(5.70)	(0.57)	(0.36)	(1.99)	(0.21)	(0.07)	(13.22)	(1.31)	(0.30)
Flood delayed	13.96***	4.28***	-0.18	11.15***	2.69***	-0.18***	32.05***	3.68***	-0.32
	(4.79)	(0.56)	(0.30)	(1.94)	(0.19)	(0.06)	(11.96)	(1.19)	(0.25)
Age	0.26	0.00	0.02*	0.38**	0.11***	-0.00	0.74**	0.05	0.00
	(0.21)	(0.03)	(0.01)	(0.15)	(0.02)	(0.01)	(0.37)	(0.03)	(0.01)
Age^2	-0.00	0.00	-0.00*	-0.00*	-0.00***	0.00	-0.01	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Child	0.52	0.08	-0.09	2.13***	0.20***	-0.03	-0.84	-0.02	-0.06
	(1.52)	(0.17)	(0.06)	(0.76)	(0.08)	(0.02)	(2.53)	(0.24)	(0.07)
Dependency ratio	-6.76***	-0.82***	0.23**	-1.97	-0.57***	0.04	4.21	0.58	0.04
	(2.22)	(0.26)	(0.11)	(1.53)	(0.16)	(0.05)	(4.53)	(0.48)	(0.15)
N. different crops	0.95	0.08	0.01	0.07	-0.03	0.00	-0.37	-0.02	-0.01
	(0.93)	(0.09)	(0.03)	(0.21)	(0.02)	(0.00)	(0.85)	(0.08)	(0.02)
Share agri-workers	-3.26*	-0.34	0.15	-4.23***	-1.09***	0.04	5.09	-0.39	0.04
	(1.93)	(0.23)	(0.09)	(1.04)	(0.11)	(0.04)	(4.04)	(0.36)	(0.14)
Mother in-law	5.65***	0.71***	-0.10	2.17**	0.42***	-0.01	6.15**	0.85***	0.03
	(1.78)	(0.18)	(0.06)	(0.89)	(0.09)	(0.02)	(2.43)	(0.24)	(0.06)
Wealth quintile=2	0.00	0.00	0.00	1.43**	0.20**	-0.02	0.80	-0.29	-0.01
	(0.00)	(0.00)	(0.00)	(0.70)	(0.08)	(0.03)	(2.78)	(0.33)	(0.14)
Wealth quintile=3	0.35	0.25*	-0.06	3.14***	0.26***	-0.05	1.56	0.41	0.01
	(1.26)	(0.15)	(0.05)	(0.80)	(0.09)	(0.03)	(2.91)	(0.30)	(0.14)

Table A13: Full regression model 3 – Land owner Household level

	Female land owner (FLO)			Male land owner (MLO)			Joint/mixed land owner (JLO)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	FCS	HDDS	HHS	FCS	HDDS	HHS	FCS	HDDS	HHS
Wealth quintile=4	0.56	0.33**	-0.04	4.38***	0.33***	-0.04	1.30	0.62*	0.08
	(1.49)	(0.16)	(0.05)	(0.90)	(0.10)	(0.03)	(2.80)	(0.33)	(0.14)
Wealth quintile=5	0.12	0.20	0.03	6.46***	0.52***	-0.03	2.52	0.08	0.15
	(1.93)	(0.20)	(0.05)	(1.07)	(0.11)	(0.03)	(2.96)	(0.33)	(0.14)
Soil type: clay	-4.19**	-0.50***	0.20**	0.57	-0.01	-0.01	0.20	0.47**	-0.03
	(1.63)	(0.16)	(0.08)	(0.73)	(0.07)	(0.02)	(2.11)	(0.21)	(0.05)
Soil type: loam	-0.49	-0.08	0.04	-0.59	0.02	0.00	-0.15	0.22	0.19***
	(1.66)	(0.17)	(0.06)	(0.75)	(0.08)	(0.02)	(2.14)	(0.20)	(0.06)
Soil type: sandy	2.98*	0.11	-0.07	-0.06	-0.11	-0.05**	3.56	0.68**	0.22**
	(1.77)	(0.20)	(0.09)	(0.83)	(0.09)	(0.02)	(2.44)	(0.26)	(0.09)
Soil type: clay-loam	1.81	0.26*	-0.06	-0.52	0.06	0.01	4.68**	0.92***	0.03
	(1.42)	(0.15)	(0.06)	(0.66)	(0.07)	(0.02)	(2.33)	(0.24)	(0.07)
Soil type: sandy-loam	-1.22	0.01	0.01	-0.15	-0.04	0.00	1.30	0.11	0.00
	(1.54)	(0.17)	(0.06)	(0.72)	(0.08)	(0.02)	(2.55)	(0.26)	(0.06)
TLU	1.26	0.03	-0.01	1.36***	0.07***	-0.00	0.41	0.03	0.00
	(0.92)	(0.08)	(0.02)	(0.27)	(0.02)	(0.00)	(0.43)	(0.03)	(0.00)
Shock: death main earner	-2.82*	-0.20	0.04	0.26	0.57**	-0.01	-4.25	-0.24	0.10
	(1.55)	(0.18)	(0.07)	(3.02)	(0.29)	(0.08)	(2.63)	(0.25)	(0.10)
Education HH-head	0.81	0.15***	0.01	0.67*	0.22***	0.01	0.45	0.07	0.00
	(0.52)	(0.06)	(0.02)	(0.37)	(0.04)	(0.01)	(0.93)	(0.09)	(0.03)
Plot size	0.02**	0.00***	0.00	0.01**	0.00	0.00	0.02***	0.00**	0.00
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Migrant	-2.20**	0.01	0.04	1.01*	0.13**	0.01	-1.26	0.02	-0.00

Table A13: Full regression model 3 – Land owner Household level

	Female land owner (FLO)			Male land owner (MLO)			Joint/mixed land owner (JLO)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	FCS	HDDS	HHS	FCS	HDDS	HHS	FCS	HDDS	HHS
	(1.01)	(0.11)	(0.04)	(0.54)	(0.05)	(0.02)	(1.90)	(0.19)	(0.05)
Cash assistance (PPP17)	333.75***	78.06***	-7.77**	331.14***	72.60***	-2.53***	610.00***	109.13***	-1.41
	(63.72)	(7.28)	(3.28)	(32.30)	(3.05)	(0.92)	(132.23)	(13.12)	(2.67)
Rice assistance (kg)	0.12	0.06***	-0.00	0.08	0.06***	-0.01**	0.79	0.18**	0.01
	(0.18)	(0.02)	(0.01)	(0.10)	(0.01)	(0.00)	(0.60)	(0.07)	(0.01)
Savings (pc PPP17)	-0.23	-0.02	-0.01	0.17	0.01	-0.00	-0.50	0.05	0.00
	(0.47)	(0.04)	(0.01)	(0.11)	(0.01)	(0.00)	(0.31)	(0.04)	(0.01)
Self-sufficient rice	-0.18	0.15	-0.09*	1.68***	0.26***	-0.06***	1.45	0.09	-0.11*
	(1.36)	(0.14)	(0.05)	(0.55)	(0.05)	(0.01)	(2.16)	(0.21)	(0.06)
Plot use: agriculture	-0.12	-0.33**	-0.05	-0.22	0.13*	-0.02	-2.55	0.21	0.02
	(1.54)	(0.16)	(0.05)	(0.74)	(0.07)	(0.02)	(2.81)	(0.22)	(0.08)
Plot use: fisheries	0.07	0.00	-0.05	0.28	0.18***	-0.03	-2.20	0.02	-0.02
	(1.59)	(0.16)	(0.05)	(0.73)	(0.07)	(0.02)	(1.96)	(0.17)	(0.05)
Plot use: homestead	-12.69***	-2.66***	-0.06	-2.70	-0.31	0.05**	16.48*	0.93	-0.29
	(4.44)	(0.63)	(0.20)	(2.73)	(0.24)	(0.03)	(8.41)	(0.57)	(0.53)
Plot use: non-agriculture	3.31***	0.23*	-0.09**	1.61***	0.19***	-0.01	-3.01	-0.47***	0.06
	(1.27)	(0.13)	(0.05)	(0.52)	(0.05)	(0.01)	(1.90)	(0.18)	(0.05)
Crop type: local variety	-0.54	-0.02	-0.08	-1.08*	-0.11*	-0.02	-4.47*	-0.08	0.01
	(1.95)	(0.21)	(0.06)	(0.59)	(0.06)	(0.01)	(2.48)	(0.23)	(0.04)
Crop type: HYV	-2.41	0.09	-0.01	0.85	0.12	-0.02	2.42	-0.22	0.03
	(2.18)	(0.22)	(0.07)	(0.74)	(0.08)	(0.02)	(3.19)	(0.28)	(0.08)
Crop type: hybrid	-0.68	-0.33	-0.03	0.85	0.17**	-0.01	-2.64	-0.18	-0.01
	(2.94)	(0.29)	(0.09)	(0.73)	(0.08)	(0.01)	(3.27)	(0.27)	(0.06)

Table A13: Full regression model 3 – Land owner Household level

	Female land owner (FLO)			Male land owner (MLO)			Joint/mixed land owner (JLO)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	FCS	HDDS	HHS	FCS	HDDS	HHS	FCS	HDDS	HHS
Constant	60.02***	9.22***	0.14***	60.02***	9.22***	0.14***	60.02***	9.22***	0.14***
	(0.57)	(0.07)	(0.02)	(0.57)	(0.07)	(0.02)	(0.57)	(0.07)	(0.02)
Divisions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month of interview	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,758	13,758	13,758	13,758	13,758	13,758	13,758	13,758	13,758
R-squared	0.17	0.31	0.03	0.17	0.31	0.03	0.17	0.31	0.03

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table A14: Full regression Model 3 – Land owner, Individual level

VARIABLES	BMI (FLO)	BMI (MLO)	BMI (JLO)
Flood immediate	-1.29***	-0.69***	-2.86***
	(0.41)	(0.12)	(0.71)
Flood delayed	1.00**	0.52***	1.60**
	(0.39)	(0.13)	(0.66)
Age	0.16***	0.23***	0.22***
	(0.01)	(0.01)	(0.01)
Age^2	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)
Child	-0.02	-0.07	-0.05
	(0.13)	(0.05)	(0.19)
Dependency ratio	-1.56***	-0.83***	-1.81***
	(0.23)	(0.11)	(0.36)
N. different crops	-0.09	-0.01	-0.05
	(0.06)	(0.01)	(0.05)
Share agri-workers	-0.29	-0.44***	-0.96***
	(0.18)	(0.07)	(0.29)
Mother in-law	0.31**	0.04	-0.36***
	(0.15)	(0.06)	(0.14)
Wealth quintile=2	0.00	0.05	-0.08
	(0.00)	(0.05)	(0.21)
Wealth quintile=3	0.02	0.13**	-0.10
	(0.11)	(0.05)	(0.23)
Wealth quintile=4	-0.03	0.21***	-0.15
	(0.13)	(0.06)	(0.24)
Wealth quintile=5	-0.00	0.25***	-0.16
	(0.17)	(0.07)	(0.24)
Soil type: clay	-0.24*	0.03	0.03
	(0.13)	(0.05)	(0.18)
Soil type: loam	-0.25*	-0.01	-0.19
	(0.14)	(0.05)	(0.17)
Soil type: sandy	-0.17	-0.07	0.28
	(0.14)	(0.06)	(0.19)
Soil type: clay-loam	-0.12	0.06	-0.21
	(0.13)	(0.04)	(0.18)
Soil type: sandy-loam	-0.27**	-0.07	-0.23
	(0.14)	(0.05)	(0.18)
TLU	-0.10*	-0.01	-0.02

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Table A14: (Continued)

VARIABLES	BMI (FLO)	BMI (MLO)	BMI (JLO)
	(0.05)	(0.01)	(0.02)
Shock: income loss	0.01	-0.08	-0.18
	(0.21)	(0.06)	(0.25)
Education HH-head	-0.03	0.01	0.07
	(0.05)	(0.03)	(0.07)
Plot size	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)
Migrant	-0.24***	-0.02	-0.02
	(0.08)	(0.04)	(0.13)
Cash assistance (PPP17)	16.34**	5.70**	22.91**
	(8.01)	(2.85)	(10.82)
Rice assistance (kg)	0.00	0.02***	0.03
	(0.02)	(0.01)	(0.06)
Savings (pc PPP17)	0.01	0.01*	-0.00
	(0.05)	(0.01)	(0.06)
Self-sufficient rice	0.22*	0.04	-0.26*
	(0.12)	(0.03)	(0.14)
Plot use: agriculture	-0.10	-0.06	-0.24
	(0.14)	(0.05)	(0.18)
Plot use: fisheries	-0.01	-0.02	-0.04
	(0.14)	(0.05)	(0.13)
Plot use: homestead	-3.79***	-0.31**	-0.71*
	(0.56)	(0.14)	(0.38)
Plot use: non-agriculture	-0.02	0.00	0.23*
	(0.11)	(0.03)	(0.13)
Crop type: local variety	0.17	-0.10**	0.30**
	(0.15)	(0.04)	(0.15)
Crop type: HYV	0.13	-0.04	0.38*
	(0.17)	(0.05)	(0.23)
Crop type: hybrid	0.23	0.04	0.06
	(0.19)	(0.05)	(0.20)
Constant	18.80***	18.80***	18.80***
	(0.05)	(0.05)	(0.05)
Divisions	Yes	Yes	Yes
Month of interview	Yes	Yes	Yes
Observations	42,835	42,835	42,835
R-squared	0.33	0.33	0.33

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table A15: Marital status: FNS of households headed by a female and male

HH-Head	Marital status	Variable	Obs	Mean	Std. dev.	Min	Max
Female-head	Married	BMI	1,634	20.66	2.54	11.19	25
		FCS	1,644	61.96	19.04	14	112
		HDDS	1,644	9.34	1.87	1	12
		HHS	1,644	0.14	0.56	0	6
	Not married	BMI	4,546	17.34	3.15	8.38	24.99
		FCS	1,051	54.80	18.41	14	112
		HDDS	1,051	8.60	2.04	1	12
		HHS	1,051	0.38	0.87	0	6
Male-head	Married	BMI	20,422	20.14	2.46	8.23	25
		FCS	10,703	60.29	18.85	11.50	112
		HDDS	10,703	9.14	1.87	1	12
		HHS	10,703	0.13	0.51	0	6
	Not married	BMI	16,233	16.84	3.02	6.67	25
		FCS	360	61.07	18.51	14	109
		HDDS	360	9.07	1.85	1	12
		HHS	360	0.14	0.49	0	3

Table A16: Marital status of female and male households heads

Household-head	Marital status	Freq.	%
Female-head	Unmarried (never married)	8	0.30%
	Married	1,644	61%
	Widow/widower	921	34.17%
	Divorced	34	1.26%
	Separated/deserted	88	3.27%
Male-head	Unmarried (never married)	233	2.11%
	Married	10,703	96.75%
	Widow/widower	105	0.95%
	Divorced	14	0.13%
	Separated/deserted	8	0.07%

Table A17: FNS of households headed by a married female

Gender of Land owner	Marital status	Variable	Obs	Mean	Std. dev.	Min	Max
Female (FLO)	Married	BMI	2,457	18.27	3.37	6.67	25
		FCS	938	58.71	18.80	14	112
		HDDS	938	8.98	1.94	1	12
		HHS	938	0.18	0.66	0	6
	Not married	BMI	1,807	18.60	3.11	10.17	25
		FCS	846	55.00	18.36	14	111
		HDDS	846	8.65	2.08	1	12
		HHS	846	0.34	0.81	0	5
Male (MLO)	Married	BMI	31,158	18.68	3.18	7.25	25
		FCS	9,373	60.38	18.91	11.5	112
		HDDS	9,373	9.14	1.87	1	12
		HHS	9,373	0.12	0.50	0	6
	Not married	BMI	948	18.76	2.92	7.67	25
		FCS	314	60.09	18.60	14	109
		HDDS	314	9.10	1.85	1	12
		HHS	314	0.18	0.58	0	3
Joint/Mixed (JLO)	Married	BMI	1,033	19.10	3.20	10.25	25
		FCS	307	63.36	17.96	24.5	112
		HDDS	307	9.60	1.72	4	12
		HHS	307	0.04	0.23	0	3
	Not married	BMI	866	18.89	3.24	8.81	25
		FCS	291	61.82	19.48	17.5	112
		HDDS	291	9.00	1.94	3	12
		HHS	291	0.14	0.50	0	4

Table A18: Marital status of crop-owners

Land owner	Marital status	Freq.	%
Female (FLO)	Not married	846	47.42%
	Married	938	52.58%
Male (MLO)	Not married	314	3.24%
	Married	9,373	96.76%
Joint/mixed (JLO)	Not married	291	48.66%
	Married	307	51.34%

Table A19: Additional results: Effect of cash assistance on FNS

VARIABLES	FCS	HDDS	HHS	BMI
Cash assistance (PPP17)	360.96***	80.50***	0.00	15.74***
	(26.49)	(2.73)	(0.01)	(2.13)
Controls	Yes	Yes	Yes	Yes
Month of interview	Yes	Yes	Yes	Yes
Divisions				
Constant	23.05***	2.61***	0.36**	7.56***
	(4.04)	(0.43)	(0.14)	(0.23)
Observations	13,758	13,758	13,758	42,835
R-squared	0.17	0.31	0.01	0.41

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Additional analysis: Non-linearities of treatments

The analysis of the interaction and quadratic models reveals significant insights into the impact of floods on food security and nutrition in rural Bangladesh, with important gender-differentiated results. In general, the household-level findings indicate that delayed floods improve food security and dietary diversity over time, but repeated exposure to floods tends to reverse these benefits. Specifically, the interaction model shows that while floods have a positive long-term effect on food consumption (FCS) and dietary diversity (HDDS), the combination of immediate and delayed flooding reduces these gains. This finding aligns with existing research, which suggests that households initially benefit from recovery efforts, but prolonged flood exposure leads to resource depletion and worsening food security (Skoufias et al., 2011; Carter et al., 2007).

The quadratic model similarly shows that the positive impact of delayed floods diminishes as flood exposure lengthens, particularly for food consumption and dietary diversity. This reflects the challenges faced by households in sustaining food security over time, a theme often highlighted in the literature on natural disasters (Carter et al., 2007). Body Mass Index (BMI) improves with delayed floods but is negatively affected when floods are prolonged, reflecting a gradual recovery in nutritional outcomes (Alderman et al., 2006).

The gender-differentiated results underscore the distinct impacts of floods on female-headed households, female members, and female landowners. Female-headed households benefit from floods in the long run, with positive effects on food consumption and dietary diversity, but they are more vulnerable to the negative effects of repeated flood exposure. This is consistent with research showing that women, especially those in leadership roles within households, often face greater challenges in accessing resources for recovery (Neumayer and Plümper, 2007). Female landowners also experience greater resilience in terms of food security and dietary diversity, but they too face diminishing returns over time due to structural barriers in accessing post-disaster support (Quisumbing, 2013).

To analyze these additional effects of floods on FNS, I estimate the following model specifications.

Interaction model

Household-level:

$$FNS_{ht} = X_{ht} * (\beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood delayed}_{ht} + \beta_3 \text{flood immediate}_{ht} * \text{flood delayed}_{ht} + \beta_4 X_{ht} + \beta_5 D_t + \beta_6 W_t + \delta_i + \epsilon_{ht})$$

Individual-level:

$$FNS_{iht} = X_{iht} * (\beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood delayed}_{ht} + \beta_3 \text{flood immediate}_{ht} * \text{flood delayed}_{ht} + \beta_4 X_{iht} + \beta_5 D_t + \beta_6 W_t + \alpha_i + \epsilon_{iht})$$

where X_{ht}=1 to analyse the direct effect of floods on FNS outcomes, at the household level; where X_{iht}=1 to analyse the direct effect of floods on FNS outcomes, at the individual level; where X_{ht}=*female* HH_{ht} =1 if the household head is female, =0 if male; where X_{iht}=$female_{iht}$ =1 if the individual member is female, =0 if male; where X_{ht}=*land* $owner_{it}$ =1 if female household member owns all household crops, =2 if male household member owns all household crops, = 3 if joint/mixed owner of household crops.

Table A20: Interaction model - Household/individual-level

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate	2.34	0.32	0.44***	-0.36**
	(2.22)	(0.24)	(0.10)	(0.14)
Flood delayed	15.98***	4.09***	-0.04	0.48***
	(2.19)	(0.23)	(0.07)	(0.16)
Flood interaction	-18.04***	-4.56***	-0.55***	-0.57*
	(4.67)	(0.49)	(0.19)	(0.31)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.18	0.34	0.02	0.41

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Table A21: Gender of household head/member level - Female Head and Female Member

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate	5.46	-0.31	0.41	-0.26
	(5.59)	(0.55)	(0.36)	(0.18)
Flood delayed	13.32***	3.73***	0.22	0.63***
	(3.99)	(0.52)	(0.23)	(0.22)
Flood interaction	-25.80***	-3.85***	-1.20	-0.65
	(9.79)	(1.04)	(0.75)	(0.40)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.18	0.34	0.02	0.42

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Table A22: Gender of landowner level - Female Land owner

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate	-8.84	-2.60***	0.61	-1.32**
	(7.09)	(0.73)	(0.46)	(0.59)
Flood delayed	16.89***	4.91***	-0.01	3.34***
	(5.65)	(0.71)	(0.32)	(0.50)
Flood interaction	-14.32	-2.96*	-0.51	-3.04***
	(15.15)	(1.65)	(0.62)	(1.16)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.18	0.32	0.03	0.33

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Quadratic Terms

Household-level:

$$FNS_{ht} = \mathrm{X}_{ht} * (\beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood immediate}^2{}_{ht} + \beta_3 \text{flood delayed}_{ht} + \\ + \beta_4 \text{flood delayed}^2{}_{ht} + \beta_5 X_{ht} + \beta_6 D_t + \beta_7 W_t + \delta_i + \epsilon_{ht})$$

Individual-level:

$$FNS_{iht} = \mathrm{X}_{iht} * (\beta_0 + \beta_1 \text{flood immediate}_{ht} + \beta_2 \text{flood immediate}^2{}_{ht} + \beta_3 \text{flood delayed}_{ht} + \\ + \beta_4 \text{flood delayed}^2{}_{ht} + \beta_5 X_{iht} + \beta_6 D_t + \beta_7 W_t + \alpha_i + \epsilon_{iht})$$

where X_{ht}=1 to analyse the direct effect of floods on FNS outcomes, at the household level; where X_{iht}=1 to analyse the direct effect of floods on FNS outcomes, at the individual level; where X_{ht}=*female HH*$_{ht}$ =1 if the household head is female, =0 if male; where $X_{iht}=female_{iht}$ =1 if the individual member is female, =0 if male; where X_{ht}=*land owner*$_{it}$ =1 if female household member owns all household crops, =2 if male household member owns all household crops, = 3 if joint/mixed owner of household crops.

Table A23: Quadratic model - Impact of floods on FNS: Household/individual level

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate	-2.22	-0.32	0.49***	-0.06
	(4.07)	(0.41)	(0.14)	(0.24)
Flood immediate^2	1.10	-0.72	-0.32*	-0.69**
	(5.59)	(0.54)	(0.19)	(0.29)
Flood delayed	29.10***	6.06***	-0.01	0.35
	(3.91)	(0.39)	(0.14)	(0.26)
Flood delayed^2	-28.79***	-5.14***	-0.29	-0.03
	(5.52)	(0.53)	(0.21)	(0.33)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.18	0.34	0.02	0.41

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Table A24: Quadratic model - Impact of floods on FNS: Gender of household head/member level

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate	-1.10	-2.07**	-0.09	0.42
	(9.70)	(0.92)	(0.40)	(0.32)
Flood immediate^2	0.47	1.39	0.30	-1.31***
	(13.48)	(1.22)	(0.70)	(0.40)
Flood delayed	25.75***	6.28***	0.79*	0.15
	(8.80)	(0.87)	(0.42)	(0.34)
Flood delayed^2	-31.09**	-5.77***	-1.43**	0.48
	(12.90)	(1.19)	(0.71)	(0.43)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.18	0.34	0.02	0.42

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Table A25: Quadratic model - Impact of floods on FNS: Gender of landowner level

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate	-17.90	-5.95***	-0.07	-2.51**
	(12.51)	(1.15)	(0.51)	(1.00)
Flood immediate^2	7.79	3.85***	0.80	0.40
	(17.15)	(1.42)	(0.76)	(1.23)
Flood delayed	28.98***	8.16***	0.48	5.17***
	(10.95)	(1.14)	(0.50)	(0.94)
Flood delayed^2	-24.54	-6.16***	-0.94	-4.09***
	(16.42)	(1.51)	(0.63)	(1.35)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.18	0.32	0.03	0.33

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Additional Analysis: Sensitivity test to alternative times

The purpose of this additional analysis is to test the robustness of the results and explore how floods during "normal times" (July 1-14 in the years 2013, 2014, 2017, 2018)[9] impact food security outcomes. These flood variables are constructed following the same procedure as for the other flood variables employed for the main analysis, and the data is retrieved from the same source, namely the NASA flooding maps collected by the "MODIS Near Real-Time Global Flood Mapping Project"[10].

In these alternative times models, floods generally have positive effects on food consumption and dietary diversity in the long run, while immediate impacts are less significant. Again, gender differences emerge, with female-headed households and female landowners seeing greater long-term gains, but facing similar vulnerabilities when exposed to sustained or repeated flood events. These findings align with existing research on gender disparities in disaster impacts and food security, emphasizing the need for gender-sensitive policies in climate adaptation and disaster recovery. These findings confirm the robustness of the main results and highlight that flood timing is crucial in determining its impact on food and nutrition security.

Moreover, these alternative times model confirms the findings of the Interaction model and of the Quadratic model, with delayed floods improving food security and dietary diversity, especially for female-headed households, though repeated exposure remains a challenge. Overall, these results reinforce the need for targeted support to vulnerable populations, particularly women, in the wake of natural disasters, as their recovery pathways differ significantly from those of men (Alston, 2013; FAO, 2011).

[9]The number of households that were flooded during "normal times" is lower, compared to those flooded during the usual moonsoon period (August in the years 2013, 2014, 2017, 2018), and the floods were less intense. In 2013, the 23% of households were flooded with 0.07/1 intensity. In 2014, the 42% of households were flooded with 0.09/1 intensity. In 2017, the 18% of households were flooded with 0.05/1 intensity. In 2018, the 29% of households were flooded with 0.11/1 intensity.

[10]Website: https://www.earthdata.nasa.gov/learn/find-data/near-real-time/modis-nrt-global-flood-product

Table A26: Time sensitivity model - Impact of floods in normal times: Household/individual level

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate (normal times)	2.43	0.84***	-0.10	-0.21
	(2.40)	(0.23)	(0.11)	(0.15)
Flood delayed (normal times)	10.49*	4.14***	-0.53**	-0.07
	(5.92)	(0.69)	(0.24)	(0.40)
Flood interaction (normal times)	-4.42	-8.08***	1.49***	-0.92
	(15.80)	(1.66)	(0.54)	(0.97)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.17	0.32	0.02	0.41

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Table A27: Time sensitivity model - Impact of floods in normal times: Gender of household head/member level

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate (normal times)	7.02	0.60	-0.70	0.08
	(5.07)	(0.55)	(0.43)	(0.19)
Flood delayed (normal times)	4.12	4.70**	0.39	-0.40
	(16.38)	(2.39)	(0.80)	(0.50)
Flood interaction (normal times)	-53.32	-10.01**	1.67	-0.51
	(36.70)	(4.58)	(1.78)	(1.22)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.18	0.32	0.02	0.42

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Table A28: Time sensitivity model - Impact of floods in normal times: Gender of landowner level

VARIABLES	FCS	HDDS	HHS	BMI
Flood immediate (normal times)	1.70	0.17	-0.12	0.02
	(8.47)	(0.85)	(0.28)	(0.69)
Flood delayed (normal times)	-1.67	4.57	0.32	0.80
	(23.88)	(3.41)	(1.03)	(1.68)
Flood interaction (normal times)	-24.25	-9.01	0.72	-3.26
	(56.31)	(7.04)	(1.94)	(3.47)
Controls	Yes	Yes	Yes	Yes
Observations	13758	13758	13758	42835
R-squared	0.17	0.30	0.03	0.33

Robust standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Controls include: age, education, dependency ratio, number of different crops, mother-in-law, shocks, land owned, wealth, percentage agricultural-earning activity, cash and rice assistance, remittances, migration, livestock, soil types, rice consumed from own production, plot uses, crop variety, division, month of interview.

Chapter 2

Climate, flood and attitudes toward violence: micro-level evidence from Karamoja, Uganda

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Abstract

Concerns about the security implications of climate change are increasing. The growing academic literature on the topic suggests that linkages between climate change and armed conflict are shaped by structural risk factors, but micro-level variation and mechanisms remain poorly understood and flood responses are hardly studied. In this paper, we strive to contribute to a better understanding of such micro-level patterns and investigate how flood exposure affects the support for violence in the Karamoja region of Uganda, which is characterized by many structural vulnerabilities to climate change and armed conflict. We use unique household-level survey panel data and investigate changes in survey responses following a destructive flood. Our study finds that flood exposure was associated with greater support for the use of violence. However, while we identify some adverse impacts of flood exposure on the perceived and actual socio-economic conditions of households and a decrease in perceptions of government support, these do not seem to mediate the estimated flood impact on support for violence against expectations. Our findings point to the limited explanatory power of natural hazards' economic impacts alone for conflict risk. Further investigation of causal mechanisms between climate hazards and conflict remains an important priority for future research.

JEL Classification: J; J; C

Keywords: Climate change; armed conflict; pastoralist conflict; flood impacts; attitudes to violence; Uganda

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2.1 Introduction

Global temperatures will rise considerably until the end of the century. With accelerating climate change in the decades to come, the frequency of natural hazards, such as floods, storms and droughts, will increase in parts of the world (IPCC, 2021). Concerns about implications of such developments for conflict risk are growing and research on this topic has rapidly expanded over the past decade. Overall, findings on general links are mixed, and research increasingly points to a conditional relationship where climate-related hazards increase conflict risk in some contexts but not in others (Koubi, 2019). Global and regional studies over long time periods have been crucial for identifying such patterns in a systematic way. However, our understanding of the specific pathways between climate and violent outcomes at the individual and community levels remains limited (Mach et al., 2020; von Uexkull and Buhaug, 2021). Flood risk in particular has received comparably little attention, though flood is one of the most frequently occurring climate-related disasters (CRED, 2022). This is an important knowledge gap for several reasons: First, climate-related hazard types differ in their specific impacts (Koubi et al., 2018; Ward et al., 2020). Second, without examining the micro-level, statistical associations remain black-boxed. More granular context-specific analyses are important to inform peacebuilding and conflict-prevention interventions (Mach et al., 2020; Ide et al., 2023).

In this paper, we contribute to filling these gaps. We use unique household-survey panel data from Karamoja, Uganda, which for the first time allow us to study attitudes toward violence and changes in socio-economic conditions at the individual level following a destructive flood. We hypothesize that flood exposure results in deteriorating perceived and actual socio-economic conditions and perceptions of the government. Drawing on established economic explanations of conflict, we further theorize that such impacts are plausible pathways to increased support for the use of violence following flood exposure in conflict-affected regions. Testing these expectations on data from Karamoja is suitable since the area has a long history of armed conflict between communal groups, resource-related disputes and violence involving government forces. Karamoja's politically and economically marginalized population mainly relies on smallholder agriculture. This region is thus a typical context of high vulnerability to climate change including to see climate translate into security risks (Koubi, 2019; Buhaug et al., 2021).

In line with our overarching expectation, we find that flood exposure was associated with higher support for the use of violence in Karamoja. We also observe negative flood impacts on the socio-economic conditions of households, in particular lower perceptions of the supportiveness of the government, the increased use of coping strategies and livestock loss. However, against expectations, the results do not suggest that these flood impacts mediated the observed flood impact on attitudes toward violence in this context. We conclude that further research is needed to robustly identify specific micro-level causal pathways between natural hazards and support for violence and that natural hazards' economic impacts alone seem to have little explanatory power in this high-risk context.

2.2 Previous research

Climate change will lead to unprecedented changes that threaten societies' prosperity and stability. Since pre-industrial times, the temperature on the planet has already risen by about 1.2 degrees and is projected to further increase (WMO, 2021). Climate-related hazards, such as drought and floods, are increasing and smallholder farmers, who rely on rainfall for livestock and crop production, are particularly vulnerable to climate change (Cohn et al., 2017).

Against the backdrop of these challenges, the scientific literature on the conflict implications of climate change has rapidly expanded over the past decade and often with a focus on the climate-sensitive rural economy (for recent reviews see Koubi (2019); Buhaug et al. (2021)). Research has pointed out how climate variability affects conflict dynamics through agricultural production changes and water scarcity (Caruso et al., 2016; Koren et al., 2021). Food and livestock price changes are another set of investigated climate impacts (Maystadt and Ecker, 2014). Overall, the literature points to conditional relationships between climate and conflict. For example, regions with ongoing conflicts, political marginalization, economic reliance on agriculture and low adaptive capacity see elevated conflict risk following climate-related hazards (von Uexkull et al., 2016; Koubi, 2019; Ide, 2020; Regan and Kim, 2020). While in current societies the overall impact of climate on conflict risk is judged to be rather minor relative to other factors, impacts will likely increase over the coming decades as global temperatures continue to rise (Mach et al., 2019).

Scientific research has made important progress, but there are knowledge gaps. First, specific pathways have for a long time be theorized (Barnett and Adger, 2007), yet our understanding of causal mechanisms remains relatively limited (Mach et al., 2020; Hendrix et al., 2023). The few existing studies indicate that individual responses to drought are importantly shaped by contextual factors, including trust in governmental institutions Detges (2017), the presence of resource governing institutions (Linke et al., 2018), socio-economic conditions (Vestby, 2019; von Uexkull et al., 2020) and conflict-exposure Detges (2017). Yet, even in areas with a number of risk factors in place, the few existing studies point to more complex relationships (Siddiqi, 2014; Linke et al., 2015a; von Uexkull et al., 2020). Hence these micro-level studies provide some answers to the question under what conditions – rather than how – climate translates into security risks. In contrast, impact pathways at the individual level are typically assumed rather than tested (for an exception see Vestby (2019)).

Second, the implications of floods for conflict have received little attention. There are only a handful flood-related studies which focus on variations between subnational administrative units or countries which again point to context-specific relationships and partly mixed findings (Ghimire et al., 2015; Nardulli et al., 2015; Koubi et al., 2018; Ide et al., 2021; Petrova, 2022). Yet, there is no micro-level work to our knowledge that allows us to observe individual and household responses. Floods are important to consider since they are among the most frequent natural hazards and in current societies close to a fifth of the world's population is estimated to be exposed to risks of severe flooding (Rentschler and Melda, 2020). River and pluvial flooding is projected to further increase in the coming decades due to climate change (IPCC, 2021). While slow-onset events like droughts accumulate over a longer period and often affect large areas, rapid onset events like flash floods from heavy rainfall can occur suddenly and unexpectedly and in areas that are far away from rivers. Insights from research on drought and other forms of slow-onset events is not directly transferable since opportunities for adaptation and responses to flood differ (Koubi et al., 2018; Ward et al., 2020).

Our study aims to address these gaps in earlier research. Using unique survey panel data, we for the first time are able to track households and individuals before and after a destructive flood and study variations in attitudes to violence. We do so in a high-risk region, the conflict-affected Karamoja region of Uganda, which is characterized by many structural characteristics that earlier research suggests to increase conflict risk following climate-related hazards.

2.3 Theoretical framework

Floods cause massive damage especially in lower income countries where infrastructure systems, including drainage and flood protection, tend to be less developed. Recent estimates indicate that 132 million people living in extreme poverty are directly exposed to flood risk, the majority of them in Sub-Saharan Africa (Rentschler and Melda, 2020). Conflict-affected contexts are particularly vulnerable to natural hazards and in such regions there is also a high risk of violence to recur (Collier et al., 2003; Buhaug and von Uexkull, 2021).

Floods may have diverse impacts on conflict risk, including dampening risk. For example, they could lead to blocked roads and hamper mobility of fighting actors just like other destructive rapid-onset disasters (Walch, 2018). However, overall, we expect that floods will increase conflict risk in conflict-affected contexts due to their disruptive economic and livelihood impacts. One core mechanism connecting economic impacts and inclination to take up arms is the opportunity-cost mechanism, relating to the expected utility of engaging in a conflict. This mechanism is the theoretical backbone of many existing studies on climate and conflict and economic causes of conflict. The opportunity-cost model suggests that when expected returns from fighting outweigh income from regular economic activity, an individual's inclination and motivation to join a militia or rebel group goes up (Grossman, 1991; Collier and Hoeffler, 2004). With reduced well-being due to lowered income and food provision, individuals have less to lose and hence are more susceptible to recruitment by militias or criminal groups, all else equal. These economic motivations have been linked to different forms of violence, including crime, civil war and genocidal violence (Verwimp, 2005; Blattman and Annan, 2016).

The importance of perceptions

Perceptions matter in this relationship in different ways. Individuals vary in their ability to handle crises and recover even under the same objective conditions (Jones and d'Errico, 2019a; Jones and Ballon, 2020). This means that equal economic impacts of a disaster are subjectively experienced differently by different individuals, who also have different perceptions about their ability to recover. If the opportunity-cost model described above is correct, this will mean that one source of variation in expected utility of conflict are differences in such perceived losses.

Perceptions also matter for an alternative explanation of the link between economic hardship and conflict. Indeed, a worsening of the economic situation may also be linked to dissatisfaction and grievances in turn resulting in higher support for violence (Rustad, 2016; Dyrstad and Hillesund, 2020). An additional important aspect for political violence, both from a grievance and opportunity-cost perspective, is perceptions of the disaster response of the government. Low regard of the government's supportiveness is plausibly indicative of perceptions of having few outside options in times of crises. This means that those who do not see the government as supporting them in a disaster should have low opportunity costs to engage in conflict. In addition, poor state response to disasters may lead to economic grievances that motivate opposition directed against the government which could, together with other factors, contribute to violent uprising (Detges, 2017; Buhaug et al., 2021).

In this study, we focus on support for the use of violence. Studying this outcome is relevant since there is ample experimental and observational research finding that attitudes and behavior go together: individuals who support the use of violence are also more likely to be involved in violence and attitudes can be used to predict later use of violence (Seddig and Davidov, 2018; Nunes et al., 2022). Moreover, those who generally support violence will support their family and community members' use of violence, which is in turn important for driving others to take part in conflict (McDoom, 2013). Notably, the economic explanations we refer to here do not point to a specific target of the violence, so support for the use of violence may include violence against the state, between communal groups or against civilians. Based on this theoretical framework we present the following hypotheses.

H1: Exposure to flood increases support for violence in fragile and violence-prone contexts

H2: The increase in support for violence following flood exposure in violence-prone contexts is mediated by deterioration in actual material well-being

H3: The increase in support for violence following flood exposure in violence-prone contexts is mediated by deterioration in perceived well-being

H4: The increase in support for violence following flood exposure in violence-prone contexts is mediated by decrease in perceived government support

2.3.1 Empirical context

Karamoja is located in north-eastern Uganda and spans around 27,000 square kilometers, around the size of Belgium (Stites and Howe, 2019). With a total population of 1.2 million out of which 60% live in absolute poverty, this rural region is the least developed of Uganda (of Statistics, 2017). Administratively, it is a sub-region further divided into districts, counties and sub-counties. Karamoja covers three agro-ecological zones. It has arid pastoral land at the border to Kenya as well as semi-pastoral and agricultural lands. Traditionally, the local population combines mobile livestock keeping with semi-sedentary farming. Due to frequent crop failures livestock are of great importance for sustenance.

Internal migration is a traditional strategy to cope with tough life conditions in the area. This takes the form of seasonal migration of pastoralist households.

Karamoja has a long history of violence. The region saw intense fighting between communal groups until 2009 resulting in hundreds of deaths. A combination of a top-down sustained disarmament campaign initiated by the Uganda government and grass-roots peace initiatives are two reasons cited for why conflict violence decreased thereafter for a decade (Stites and Howe, 2019). However, from 2019 on violence increased again. Local newspapers claim hundreds were killed in cattle raids as well as in clashes with government forces (Oketch and Otwii, 2021; News, 2022). Violence since the beginning of our study period in 2016 has taken form of large-scale communal raids including involving groups from across the border to Kenya, high rates of individual opportunistic theft as well as violence involving government forces against alleged raiding groups (Stites and Howe, 2019; Abrahams, 2020; News, 2022).

Karamoja has a variable climate with persistent droughts as well as occasional floods caused by water from heavy rains running from higher to lower-lying areas. In 2018, a particularly severe flood event occurred, which is the event in focus in our study. Karamoja experienced the wettest March to May period on record in 2018 and over 180,000 Ugandans were affected (Ssekandi, 2018). While crops developed normally in higher-elevation areas, in lowland areas persistent flooding and subsequent waterlogging caused crop damage and led to high pest incidences amounting to an estimated 60 to 80 percent crop loss (NET, 2018). Further, the heavy floods hampered access to markets, hospitals and schools. Some river banks were destroyed and river water was contaminated with waste. This caused water borne diseases, malaria and child malnutrition in addition to direct deaths in the floods (ActionAid, 2018).

2.4 Research design

We study survey responses following the 2018 flood in Karamoja based on novel sub-nationally representative panel household-survey data, collected in 2016 and 2019. Households are understood as group of individuals sharing common living arrangements, which thus form a unit of individuals with shared and mutually dependent economic status and decisions. Using panel data comes with several advantages. First, we are able to track over-time changes in characteristics that we theorize shape support for violence. Panel data also has methodological advantages. Focusing on changes over time is an important safeguard to biases resulting from temporarily constant traits such as livelihoods and general incentives to misrepresent information in surveys.

2.4.1 Data collection and sample

Data collection in conflict-affected regions is challenging for many reasons, such as limited access to relevant population groups and high costs. Here, we overcome the logistical challenges by using data originally collected by United Nations (UN) organisations in monitoring and evaluation efforts but with activities and beneficiaries selected unrelated to the flood. The data collection aimed at collecting household-level data representative for Karamoja in 2016 with follow up of the same household 2019. It targeted household heads. For details on supplementary material cf. Appendix Section A.

The most comprehensive representative sample consists of 2156 households interviewed in 2019. Out of these the vast majority, 1965 households, were already included in 2016 (i.e., composing a balanced panel). 1640 in addition had the same respondents within the households in both rounds. In order to maximize representativeness, we use the panel data of households interviewed in both rounds for main models, and the individual-level panel for robustness with additional results documented in the Appendix.

2.4.2 Variable operationalization

Our main measure for flood is self-reported data on flood exposure within the past 12 months. The variable flood is coded '1' if a respondent reports flood shock exposure in response to the question *"In the last 12 months, which of the following shocks did your household experience?"* and '0' otherwise. Using this data has the important advantage that it allows us to capture impacts on the 53% partly mobile pastoralist households in our sample. Given mobility, it is more uncertain to what degree households in specific locations at the time of the survey really were affected. The survey data will capture this since the same households are interviewed again. We find this self-reported variable to be positively correlated with extreme rainfall in relevant months using highly disaggregated rainfall data which provides further evidence that the self-reported data is able to capture changes in the natural environment (Table A2.8).

Material well-being

The sources of income and material well-being generally differ across contexts and households. To be able to account for different local livelihoods we focus on several dimensions of socio-economic conditions: crop production (cropharvest measured in 100kg in the main models), livestock ownership (measured in Tropical Livestock Units, *tlu*), and composite indices of wealth measuring assets owned by the household (*wealth index*), food security (Food Consumption Score, *fcs*) and use of different coping strategies to shocks (Coping Strategy Index, *csi*). *csi* measures for how many days in the past seven days different coping strategies, such as gathering wild food and reducing meal sizes, were adopted. *Csi* is adapted to local conditions being informed by FAO-led focus group discussions on relevant coping strategies to shocks conducted in Karamoja before implementing the survey.

Subjective conditions

For capturing relevant perceptions, we focus on subjective capabilities and capital drawing on resilience research (Jones and d'Errico, 2019a; Jones and Ballon, 2020). In line with the theoretical framework and our interest in studying attitudes to violence, we mainly focus on *absorptive capacity*, *transformative capacity*, *financial capital* and *political capital*. The letter covers government supportiveness. Subjective capacities are measured on a five-point scale, ranging from 'strongly agree' (1) to 'strongly disagree' (5).

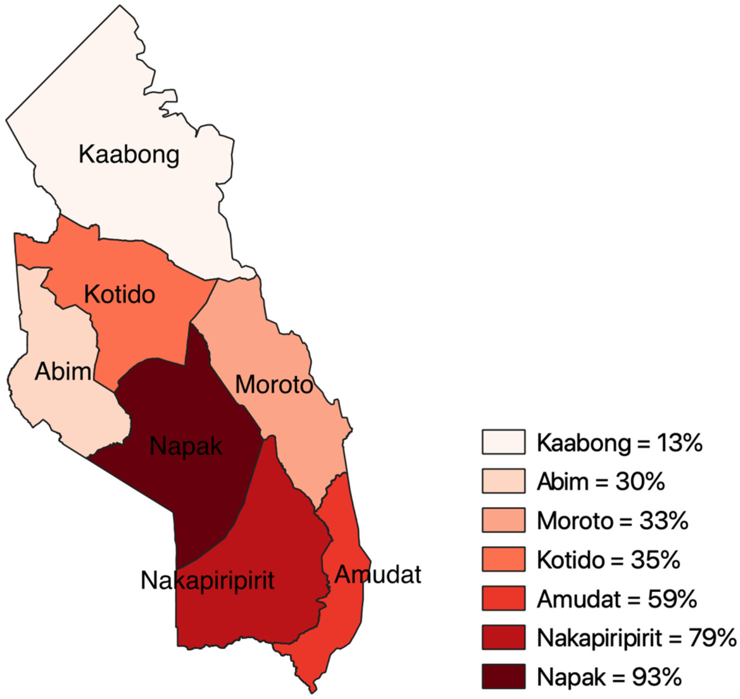

Figure 2.1: Percentage of surveyed population reporting flood exposure in 2018-2019 within districts (2016 district boundaries)

Details on the variables composing the respective indices are provided in the supplementary material (Table A2.5 and A2.6)

Measuring support for violence

Measuring support for violence and conflict is notoriously difficult and sensitive. In line with earlier studies, we use survey questions that are adapted from the Afrobarometer, a survey routinely conducted in a number of African countries. We ask Which statement do you agree with and how much? 1) The use of violence is never justified in Ugandan politics. 2) It is sometimes necessary to use violence in support of a just cause. 3) None of the above. Response options for the first and second option are support and strongly support. We turn this variable into a dummy variable coded '1' for the second option, and '0' for the first and third option and missing otherwise.

Using a very similar question on political violence as earlier work is useful for accumulating of knowledge on support for violence across contexts (Linke et al., 2015a; Detges, 2017; von Uexkull et al., 2020). This question is relatively broad but refers to the local Ugandan context to make sure it is relevant and specific enough. It focuses on political violence, which is important to exclude intra-household domestic violence and abuse which are also widespread in Karamoja (Stites and Howe, 2019). Given this particular rural context and history of cattle-raiding, in alternative tests, we also investigate support for stealing in response to hunger to capture conflict behavior that is not explicitly political in nature, but that is a frequent feature of violence along communal lines (Table A2.9). We conduct further robustness checks on alternative ways of coding responses to the main variables (Table A2.15).

Naturally, individuals who support the use of political violence may not act upon their attitudes. However, research in social psychology finds that questions on attitudes to specific behaviors predict actual behavior in many domains, including violence, reasonably well (Seddig and Davidov, 2018; Nunes et al., 2022). Not all individuals will answer truthfully to this question, which may be seen as sensitive. Overall, we expect that estimated support rates are attenuated toward zero. People who are in effect supportive of violence may be inclined to say they are not due to social desirability biases. This likely downward bias will make it harder for us to identify significant relationships.

Estimation strategy and control variables

We only have data from 2019 for many conflict-related variables, but a rich set of panel observations of material and subjective changes. Our identification strategy combines different approaches that each have particular strengths for identifying causal effects and thus are employed complementarily, to make optimal use of the rich dataset. In short, we (1) establish the direct relationship between flood exposure and support for violence in the cross-section to test the first hypothesis. We then (2) study flood impacts on material and subjective conditions using difference-in-differences (DID) estimation using a household-level panel and, (3) perform a causal mediation analysis to investigate specific pathways and test the second and third hypotheses.

In the first step estimating the direct effect of flood on support for violence, y is the observed binary conflict-related outcome for respondent i, α is the intercept, β is a vector of coefficients for a set of respondent-specific variables including flood, d are district fixed effects and ϵ is the error term.

$$y_i = +\beta x_i + +d + \epsilon_i$$

The district fixed effects account for potential unobserved features of particular regions such as elevation and land-use, which may make specific areas both conflict and flood-prone. As we are estimating the effect of flooding, i.e. hydrological processes that affect whole villages, we in addition account for spatial dependence by employing corrected Conley standard errors, which have 10 km as cut-off point (Hsiang, 2010).

As a second step, we start unpacking causal mechanisms. We estimate the flood impacts on material well-being and subjective assessments. DID is a powerful design-based method frequently used in impact assessments assuming parallel developments in the absence of a ‘treatment’, here the flood shock (Gertler et al., 2016).

We estimate the following equation:

$$y_i = \beta_1 treated_i + \beta_2 time + \beta_3 treated_i * time + +\beta_4 Z + d + \epsilon_i$$

where y is the observed binary conflict-related outcome for respondent i, α is the intercept, β is a vector of coefficients for a set of respondent-specific variables, including *treated* which is flood-shock exposure; *time*, which is a dummy for the later survey round, as well as the interaction term which specifies the difference-in-difference estimator; controls Z, district fixed effects d. ϵ is the error term.

In a third step, we then estimate whether changes that are attributed to the flood in second step were indeed associated with increased support for violence using causal mediation techniques (Imai et al., 2011). Since our unique panel data allows us to specify the change in the potential mediating variables over time from pre- to post-flood periods measured for exactly the same household, we should be able to pick up the potential mediating effect.

Our main choice of control variables is informed by earlier research and balance tests across respondents that are flood-affected compared to those who are not (Table A2.2). While the sample is balanced across most variables there are a few significant differences. Flood-affected households received more aid in 2016, are less likely pastoralist and respondents are more likely female, with the latter variable only being significant at the 90% level. To account for these differences, we control for sum of formal transfers received by the household per capita, measured in 2016, logged (*log fortransfers*). This variable includes all formal transfers to the household in the preceding 12 months from different sources, e.g. food for work from NGOs and government pension funds. We also include binary variables for pastoralist livelihood (*pastoralist*) and female respondent (*female*) respectively, in main models.

In extended models, we add a battery of potential other determinants of support for violence informed by earlier survey research on this topic (Detges, 2017; Linke et al., 2018). Specifically, we control for drought exposure (*drought*)[1] to account for other shocks, as well as the food consumption score (*fcs*). Lastly, we also aggregate yearly deaths from conflict and protest (*fatalities acled*) of any type during the years 2012-2016 pre-survey implementation from the ACLED dataset (Raleigh et al., 2010) and merge it at the district level with the household data. Controlling for fatalities aims to capture potential impacts of conflict exposure on attitudes toward violence.

2.5 Results

We proceed to presenting the results starting with the direct relationship of flood and attitudes toward violence and then moving on to the hypotheses on what may explain this relationship. First, in Table

[1]Drought is a slowly changing omnipresent condition in the region affecting almost everyone in the sample throughout the study period. This makes it important to account for drought in the statistical model, though it difficult to assess drought impacts since almost everyone reported drought exposure throughout the survey rounds (70-88% of respondents) (cf. Table A2.1). This means that we do not have a comparison group for drought unlike for flood.

2.1, Models 1 to 3, we estimate models of support for violence using self-reported flood as independent variable. Model 1 includes only flood, Models 2 and 3 add a limited and extended set of control variables, respectively. For all models, we find flood to be positively associated with support for violence and the size of the coefficient for flood is hardly affected by the inclusion of additional variables. Since not all conflict and violence is political in Karamoja we test the robustness of this finding to using support for stealing when going hungry and resource disputes as alternative dependent variables. The coefficients of the flood indicator are positive, but not significant (Table A2.9).

Additional control variables are interesting in themselves and provide tentative support for the relevance of economic motives for supporting violence in this area. Models 3 and 4 indicate that the food consumption score (*fcs*), a common indicator of food security, is negatively related to attitudes to violence so that respondents from comparably food secure households are less likely to support the use of violence. In contrast, drought, gender and pastoralist livelihoods and earlier fatalities in the region are not significant at conventional levels.

Table 2.1: Cross-section analysis flood and support for violence

Variables	(1)	(2)	(3)
Flood	0.058***	0.059**	0.059**
	(0.023)	(0.023)	(0.025)
Drought			-0.009
			(0.023)
Pastoralist		0.010	0.008
		(0.020)	(0.018)
Female		-0.022	-0.026
		(0.023)	(0.023)
Log fortransfers		0.002	0.001
		(0.007)	(0.007)
Fcs			-0.003***
			(0.001)
Fatalities acled			0.070*
			(0.036)
Constant	-0.001	0.014	0.016
	(0.030)	(0.032)	(0.066)
District FE	Yes	Yes	Yes
N	1,958	1,958	1,958
R-squared	0.193	0.194	0.211

Conley-Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.5.1 The impact of flood on households' material and subjective well-being

Next, we investigate flood impacts on material and subjective socio-economic conditions as a first step to identifying potential pathways to the support for violence. Here, we can fully leverage the panel dataset using the difference in differences design.

The coefficients from the DID models are visualized in Figure 2.2 and full models are presented in the Appendix (Tables A2.10-A2.11). We find that flood exposure is significantly related to a decrease in livestock and to an increase in days spent on different coping strategies, while flood is unrelated to crop harvests, wealth and food consumption in our sample. For livestock, the estimated flood effects of 0.3 on *tlu* correspond to the loss of one pig and one goat, for example. For coping strategies, the difference corresponds to another day spent on a coping strategy to deal with food insecurity in the past seven days, such as skipping a meal.

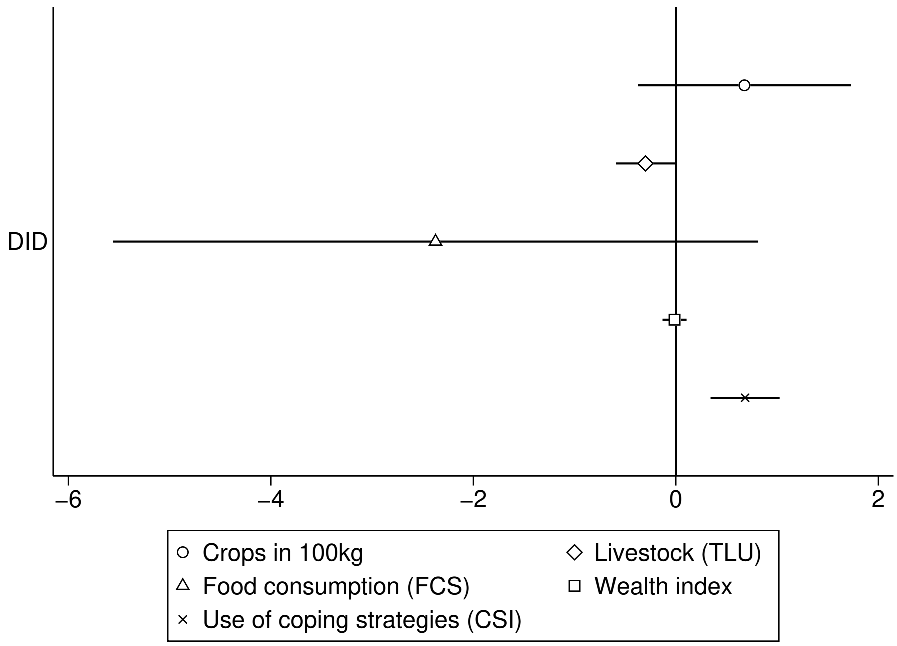

Figure 2.2: Flood impacts on material conditions. DID estimator (flood x time) for different dependent variables indicated in the legend, controlling for pastoralist livelihood, log per capita formal transfers and district fixed effects, same household panel sample. Full models are provided in the appendix (Table A2.10).

We then turn to the subjective assessment of conditions using the same modeling choices. For interpreting Figure 2.3 note here that larger numbers indicate adverse changes. For these models, only estimated flood effects on political capital are statistically significant with floods exposure associated with a more negative view on the responsiveness of governments and politicians in times of crises. The findings displayed here are substantively unchanged when using the same respondent sample (Table A2.13 and A2.14).

2.5.2 Mediation analysis

In a third step, we estimate whether the changes that are attributed to the flood in the DID models above – henceforth referred to as candidate pathways – were indeed associated with increased support for violence using the causal mediation analysis model. We implement the causal mediation model using the *medeff* package, developed in Stata by Hicks and Tingley (2011). The function estimates a first-stage

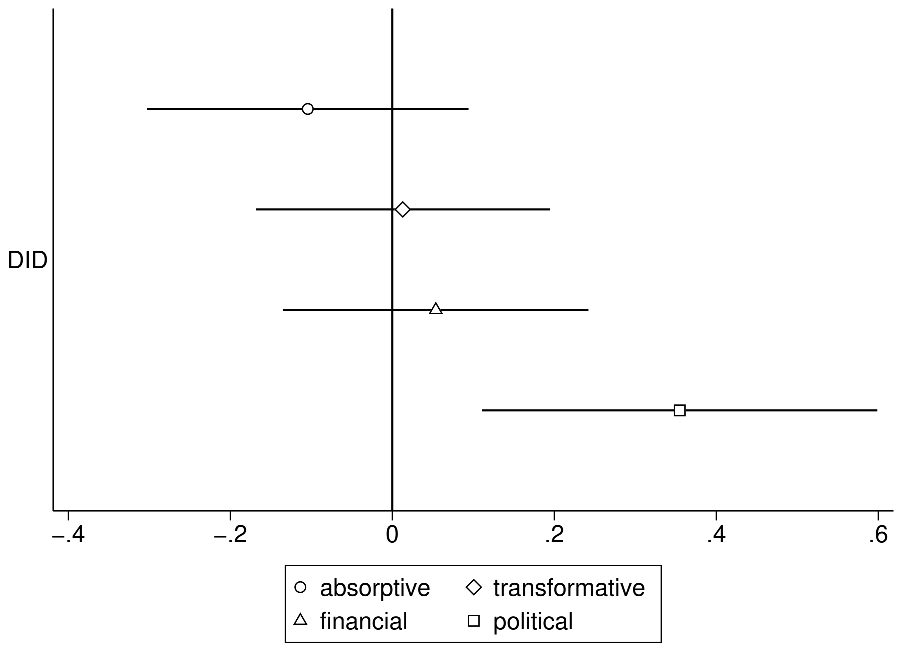

Figure 2.3: Flood impacts on subjective conditions. DID estimator (flood x time) for different dependent variables indicated in the legend, controlling for pastoralist livelihood, log per capita formal transfers and district fixed effects, same household sample. Full models are provided in the Appendix (Table A2.11).

model in which the mediator (in our case the change in *TLU*, *CSI* and *Political capital*, respectively) is regressed on the independent variable (*flood*) and additional covariates as in the main models; and a second-stage model that predicts the dependent variable (support for violence) as a function of the mediator as well as the independent variable and covariates in a probit model[2].

In line with results visualized in Figures 2.2 and 2.3, we estimate whether changes in livestock, coping strategies and political capital mediate the flood-violent attitude relationship. As is visible in Table 2.2, none of the average causal mediation effects (*ACME*) are statistically significant. In contrast, the average direct effect of flood and total effect, indicate significantly increased support of violence for the flood-exposed. Hence, we again find that flood is associated with support for the use of violence in line with initial models on the flood-violence relationship presented in Table 2.1. However, contrary to our theoretical expectations, livestock losses, increasing use of coping strategies and failing trust in government support were not significant mediators of this relationship (the ACME confidence intervals always include 0).

Table 2.2: Causal mediation analysis of flood effects on support for violence

Mediator	Effect	Mean	[95% Conf.	Interval]
Livestock	ACME	-0.0004	-0.0024	0.0008
	Average Direct Effect	0.0487	0.0148	0.0862

[2]Results on mediators are substantively unchanged with a logistic regression model (not shown), but only probit is supported in the package that allows for sensitivity analysis.

Table 2.2: Causal mediation analysis of flood effects on support for violence

Mediator	Effect	Mean	[95% Conf.	Interval]
	Total Effect	0.0484	0.0138	0.0855
Coping Strategies	ACME	0.0001	-0.0015	0.0019
	Average Direct Effect	0.0478	0.0137	0.0854
	Total Effect	0.0480	0.0135	0.0853
Political capital	ACME	-0.0040	-0.0100	0.0012
	Average Direct Effect	0.0492	0.0152	0.0866
	Total Effect	0.0456	0.0103	0.0824

Note: Average Causal Mediation Effect (ACME). Controls for (log) formal transfers in 2016, pastoralist livelihood, female respondent, district fixed effects.

Identifying mediation relies on strong assumptions - sequential ignorability - about both the mediator and the outcome model, which cannot be tested with the observed data (Imai et al., 2011). Sequential ignorability assumes that there are no unmeasured confounders for the intervention to mediator pathway and the mediator to outcome pathway. We therefore employ sensitivity tests to quantify how results would change if the sequential ignorability assumption was relaxed (Imai et al., 2011).

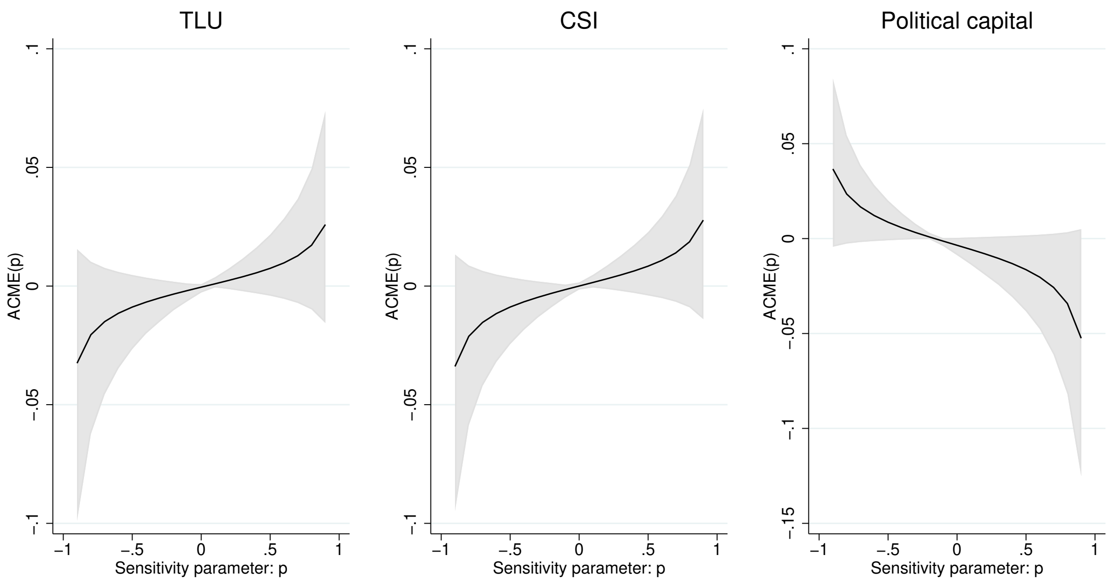

Figure 2.4: Sensitivity analysis plot. The figure displays the sensitivity of the ACME with respect to 467 the error correlation for each mediator (ρ), at the 95% confidence interval.

We estimate the ACME for different levels of the sensitivity parameter ρ indicating the correlation between the residuals from the mediator and outcome model respectively. Figure 2.4 displays how varying levels of ρ, between -1 and +1, influence the ACME. A sensitivity parameter of 0 represents null hypothesised levels of residual confounding and the extremes of -1 and 1 represent maximum hypothesised levels of residual confounding. We find that the confidence interval of the ACME (limits represented with a grey background) always includes zero for the indirect effect whatever the value of ρ. Hence, the results of the sensitivity analysis further support the absence of a significant mediation effect of the candidate mediators identified.

2.6 Conclusions

Climate change has often been referred to as threat-multiplier (NATO 2021). While the term as such is debated, this study follows its underlying conceptual logic by investigating the impact of flood on support for violence in a region that is already grappling with a multitude of security and development challenges. The study provides evidence for the impact of flood on support for violence based on self-reported flood-exposure data. This is an important result given the mixed findings on flood and conflict in the few existing research works, which point to conditional relationships (e.g., Ide et al. (2021); Petrova (2022)).

As a second contribution, we assess candidate pathways through which this estimated flood effect may have materialized using unique household and individual-level survey panel data. We on the one hand find that flood exposure was associated with a modest increase in the use of coping strategies, as well as loss in livestock and perceived political capital. One the other hand, against expectations, changes in these variables did not correlate as expected with support for violence and mediation analysis did not support that these factors were mediating the estimated direct, total, flood effect on attitudes to violence. In light of the theoretical framework, we therefore conclude that the estimated economic impacts of natural hazards seem to have limited explanatory power for the flood-violence relationship based on the data we have.

These mixed findings from the Karamoja region are in line with earlier research on climate-related shocks which suggests that pathways are highly context-specific and that point to the limited explanatory power of analyses focusing on economic impacts of natural hazards alone (Siddiqi, 2014; Buhaug et al., 2021). Micro-level causal mechanisms between climate and conflict thus deserve further exploration in future research. Factors pointed out by other work that may be relevant in the Karamoja context are population movements into the region as well as changes in the effectiveness of informal and traditional institutions (Linke et al., 2015a; Ide et al., 2023). Further, it may be interesting to assess in a more comprehensive way how food security relates to conflict participation. The findings presented here indicated that respondents from comparably food secure households were less likely to support the use of violence.

While we were able to track hazard impacts over time in this work, which is unique in the study of climate and conflict, we at the same time acknowledge limitations. Panel data comes with important advantages for causal identification of flood impacts and the unique data allowed us to track responses over time in this study. However, we only had two rounds of survey data which limited our ability to track effects and recovery from flood impacts. Hence, further research would benefit from frequent surveys that allow for tracking impacts and recovery from climatic hazards and changes in attitudes to - and experience of - violence. Implementing several rounds of follow-up surveys via phone or SMS could be a promising and efficient avenue (Jones and Ballon, 2020).

What implications do our results have for explaining violent conflict? While we study attitudes and not behavior, the general link between support for and the use of violence has been established elsewhere (Linke et al., 2015b; Nunes et al., 2022). Karamoja's violent history points to mobilization potential as seen in the latest deadly cattle raids and gun violence. Based on our findings, violence could be further spurred by flooding and related climate-hazards in this marginalized region of Uganda, but focusing on dampening economic effects of hazards alone may not be effective for preventing this.

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Appendix

Data collection details

Data collection in conflict-affected regions is challenging for many reasons, such as limited access to relevant population groups and high costs. Here, we overcome the logistical challenges by using data originally collected by United Nations (UN) organisations in monitoring and evaluation efforts. Karamoja has been the target of UN programs for many years and in 2017 the Joint Resilience Strategy aimed at enhancing the resilience and food security of vulnerable households. The three UN agencies involved were the Food and Agriculture Organization of the United Nations (FAO), the United Nations Children's Emergency Fund (UNICEF) and the World Food Programme (WFP). They respectively implemented the interventions Junior Farmer Field and Life Schools (FAO), improved access to Water, Sanitation and Hygiene (WASH) for schools (UNICEF) and a school feeding programme (WFP). The agencies targeted some of the same sub-counties in the districts of Amudat, Kotido, Moroto and Napak during 2017 and 2018 for their interventions. The rest of the sub-counties were targeted not in combination of the UN agencies, but could have been targeted by other interventions. Importantly, the program did not address flood impacts and the selection of sub-counties were independent of flood risk. The data we use in this study is composed by two datasets collected before and after the UN programs were implemented: the first one during November and December 2016 and the second one in February 2019.

The general data collection strategy aimed at collecting household-level data representative for the whole Karamoja region with the original purpose to evaluate the Joint Resilience Strategy pursued by the involved organizations. The data collection for the household survey was carried out using Computer-Assisted Personal Interviewing (CAPI) methods using digital tablets for conducting interviews. The questionnaire generally followed questionnaires adopted in other contexts by the implementing organisations. It was adjusted following discussions with the enumerators recruited from Karamoja and a small pilot in one village.

In the first round of data collection in 2016, a random sample of households was selected in each village according to the following procedure. The survey supervisor asked the chief or village elder about the number of households living in the village or obtained this information in a household list where available. The total number of households was divided by the number of interviews needed from the village to achieve a representative sample calculating the Sampling Interval, SI. Each enumerator randomly chose a number between 1 and the SI, the Random Start RS. They then started counting the households moving in one direction and selecting the RS; then RS+SI; then RS+SI+SI... until the required number was reached.

The survey generally targeted household heads. In case of absence of the household head enumerators were instructed to approach the most knowledgeable adult present. Analysing respondent characteristics revealed that for most households in the sample other female family members were interviewed such as wives, sisters or granddaughters to the household head presumably since they were more likely at home at time of the interview (Table A2.1). The skewed gender distribution is a limitation of the study since the local population are predominantly pastoralists for whom the use of violence is mainly associated with males (e.g., in the context of cattle-raids (Stites and Howe, 2019)). Yet, it is known women importantly influence the use of violence in pastoralist societies by upholding norms and socially sanctioning deviations from expected behavior. Hence, the rate of support for violence among women are important for the behavior of their household and community members even if they themselves are less likely to take up arms.

Descriptives

Table A2.1: Descriptive statistics

Variable	N	Mean	SD	Min	Max
Violence justified	1958	0.13	0.34	0.00	1.00
Steal justified	2028	0.04	0.20	0.00	1.00
TLU	2156	0.94	1.52	0.00	10.54
FCS	2156	39.11	15.23	4.00	100.00
Crop harvest (kg)	2156	99.34	773.75	0.00	35000.00
Eealth index	2156	-0.00	0.80	-1.38	3.56
Flood	2156	0.50	0.50	0.00	1.00
Flood severity	2156	1.77	1.84	0.00	4.00
Drought	2156	0.70	0.46	0.00	1.00
Drought severity	2156	2.36	1.64	0.00	4.00
Absorptive	2156	2.58	1.09	1.00	5.00
Transformative	2156	2.91	1.10	1.00	5.00
Financial	2156	2.02	0.95	1.00	5.00
Political	2156	2.57	1.26	1.00	5.00
Female head	2156	0.27	0.44	0.00	1.00
Female	2156	0.84	0.36	0.00	1.00
Education	2156	1.99	2.74	0.00	14.00
Fatalities acled	2156	0.64	1.12	0.00	3.00
Pastoralist	2156	0.53	0.50	0.00	1.00
Formal transfers(log)	2129	0.31	0.93	0.00	6.30
Improved toilet	2156	0.10	0.31	0.00	1.00
Water availability	2156	11.64	1.16	1.00	12.00

Table A2.1 displays descriptive statistics of the full 2019 data collection round.

Table A2.2: Pre-treatment balance for flood exposure same household sample

Variable	Mean unaffected	Mean flood-affected	Diff.	t-value
TLU	0.807	0.810	0.002	0.02
FCS	36.739	40.114	3.375	1.83
Crop harvest (kg)	199.622	148.801	-50.821	1.11
Wealth index	0.181	0.138	-0.043	1.59
Flood severity	0.548	0.858	0.310	1.80
Shock drought	0.884	0.882	-0.002	0.07
Drought severity	0.859	0.912	0.053	1.44
Absorptive	2.814	2.842	0.028	0.48
Financial	2.209	2.135	-0.074	0.65
Female head	0.200	0.213	0.012	0.31
Education	2.012	1.923	-0.089	0.41
Fatalities	1.316	0.609	-0.707	1.27
Pastoralist	0.531	0.428	-0.103**	3.14
Interview date	11.231	11.407	0.176	1.65
Female respondent	0.818	0.884	0.066*	2.00
Formal transfers (raw)	2.753	4.373	1.620**	2.72
Improved toilet	0.245	0.113	-0.132	1.71
Water availability	11.307	11.429	0.122	0.89

***p<0.01;**p<0.05;*p<0.1

Table A2 displays the results of a balance test according to treatment status (flood experience) across a number of variables measured in 2016. The comparison shows that flood affected households were less likely pastoralist, and received more transfers in the pre-treatment period before the flood hit. The table shows the respective means, differences between means, and t-values.

Table A2.3: Comparison households that remain in the sample and households dropping out

Variable	**Diff.**	**t-value**
TLU	-0.0971	(-0.71)
FCS	-0.818	(-0.66)
Crop harvest (kg)	-58.29**	(-2.78)
Eealth index	-0.0167	(-1.09)
Flood (2016)	-0.0435*	(-2.32)
Drought (2016)	-0.0400	(-1.62)
Absorptive	0.0826	(0.92)
Transformative	0.0278	(0.32)
Financial	0.0797	(1.07)
Political	0.226**	(2.70)
Female head	0.00804	(0.26)
Formal transfers (log)	0.0428	(0.56)
Female respondent	0.00724	(0.27)
Education average	0.468*	(2.18)
Fatalities (ACLED)	-0.322***	(-3.59)
Pastoralist	-0.00819	(-0.22)
Improved toilet	-0.0263	(-0.91)
Water availability	-0.0758	(-0.67)
N	2156	

t-statistics in parentheses: * p<0.05, * p<0.01, *** p<0.001

Household dropped out and replaced after 2016: 191 Household remaining after 2016: 1965

Table A2.3 provides results of a two-sample mean comparison t-test of the households that were interviewed in 2016 and could again be interviewed in 2019 to those that could no longer be followed. The comparison is done based on the 2016 data. The comparison shows that those who left the sample after 2016, as they migrated long-distance, changed their address or died differed in some respects from those staying. They harvested more, were happier with government support and were more likely exposed to conflict violence 2011-2016. The table shows the difference in means from those staying to those leaving and t-values in parenthesis.

Table A2.4: t-statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001

Variable	Diff.	t-value
Violence justified	0.0388	(1.80)
Steal justified	0.00255	(0.20)
TLU	0.0779	(0.82)
FCS	0.795	(0.86)
Crop harvest kg	-14.37	(-0.29)
Wealth index	0.151**	(3.08)
Shock flood	0.00342	(0.11)
Flood severity	0.0565	(0.51)
Shock drought	0.0236	(0.84)
Drought severity	0.0553	(0.55)
Absorptive	0.0257	(0.38)
Transformative	0.0273	(0.41)
Financial	-0.0153	(-0.27)
Political	-0.143	(-1.88)
Female head	-0.0288	(-1.06)
Female	-0.167***	(-7.61)
Education average	0.506**	(3.08)
Fatalities acled	0.257***	(3.79)
Pastoralist	-0.0393	(-1.30)
Formal transfers(log)	-0.0730	(-1.25)
Improved toilet	0.0507**	(2.73)
Water availability	-0.0213	(-0.30)
N	1965	

t-statistics in parentheses: * p<0.05, * p<0.01, *** p<0.001

Different respondent in the same household than 2016: 325 Same respondent in the same household as 2016: 1640

Table A2.4 provides a comparison of the households with a different respondent interviewed and households with the same respondent in both rounds. The comparison is based on responses in 2019. The table presents the difference in means and t-values in parenthesis.

The comparison indicates no significant differences regarding support for violence and stealing, which is reassuring. However, the comparison shows that respondents were more likely to change for households that were wealthier, more educated, which did not have a female respondent and/or were located in areas that had a history of violence. Overall, these statistics illustrate inherent challenges in obtaining representative panel data at the individual level.

Table A2.5: Material conditions measurement

Variable	Description
Tropical Livestock Unit (*TLU*)	Tlu standardizes different types of livestock into a single unit of measurement. The conversion factor adopted is: 0.7 camel; 0.5 cattle; 0.3 donkeys /mules; 0.2 pigs; 0.1 sheep/goats; 0.01 chicken.
Crop harvested	Quantity of crop harvested by the household in the previous 12 months.
Wealth index	The wealth index is created through factor analysis. A list of variables assumes the value 1 or 0 is used, depending on whether or not a household has specific non-productive assets, such as can, mill, bed, mattress, chairs, tables, lamp, solar panel, radio, mobile, and bicycle.
Food Consumption Score (*FCS*)	Score calculated using the frequency of consumption of different food groups consumed by the household during the seven days before the survey. This is a commonly used food security indicator accounting for both the supply with nutrition and calories.
Coping Strategy Index (*CSI*)	CSI is a weighted sum of the number of days that the household adopted different strategies to cope with food shortages during the past seven days. These strategies are 1) Gather wild foods, "famine foods" or hunt; 2) Harvest and consume immature crops; 3) Consume seed stock that will be needed for next season; 4) Send household member elsewhere; 5) Limit portion size at meal time; 6) Reduce consumption by adults in order for small children to eat; 7) Reduce consumption by others so working members could eat; 8) Go one entire day without eating; 9) Sell livestock; 10) Reduce number of meals eaten in a day; 11) Beg for food; 12) Selling assets (other than livestock); 13) Increase the selling of firewood and charcoal. 14) Rely on casual labor; 15) Enroll children in school (even when they are not of school-going age, in order to access food); 16) Ask for loans from villages savings. The strategies included are based on focus group discussions in 2016 conducted in Moroto, Karamoja, at the outset of the first data collection.

Table A2.6: Subjective conditions measurement

Variable	Description
Absorptive Capacity	My household can bounce back from any challenge that life throws at us
Transformative Capacity	During times of hardship, my household can change its primary source of income or livelihood if needed
Financial Capital	My household can afford all of the things that it needs to survive and thrive
Political Capital	My household can rely on the support of politicians and the government when we need help

We regard these measures as relevant in different ways: Absorptive capacity is a forward-looking measure going beyond the current status. Is the respondent optimistic about the household's robustness to shocks and its capacity to recover from any temporary challenges? Transformative capacity asks whether there are alternative livelihoods available; this question is directly related to the concept of opportunity costs to the use violence. Financial capital captures satisfaction with the current financial status. Given that violence and crime are still widespread in Karamoja, these questions capture different aspects of perceptions of well-being and capacities to respond to a shock. We also investigate political capital. Political capital is here used to indicate household's perceptions of access to resources and power brokers (Jones and d'Errico, 2019b,a). Perceptions of lack of support and responsiveness of governments may be an important trigger of grievances motivating political violence in particular (Raleigh, 2010; Buhaug et al., 2021). This specific selection of indicators is based on relevant aspects in evaluating outside options short of violence. Subjective capacities are measured on a five-point scale, ranging from 'strongly agree' (1) to 'strongly disagree' (5).

Table A2.7: Correlation of material and subjective conditions

	TLU	FCS	Crop	Wealth	CSI	Abs.	Tran.	Fin.	Pol.
TLU	1.00								
FCS	0.14	1.00							
Crop	0.09	0.06	1.00						
Wealth	0.13	0.29	0.09	1.00					
CSI	-0.02	-0.07	-0.03	-0.20	1.00				
Abs.	0.08	0.05	0.03	0.19	0.02	1.00			
Tran.	0.10	0.09	0.02	0.16	0.07	0.47	1.00		
Fin.	0.04	0.09	-0.01	0.13	0.07	0.40	0.31	1.00	
Pol.	-0.02	0.07	-0.003	0.03	0.18	0.23	0.27	0.27	1.00

Table A2.7 displays the bivariate correlation of the pathways investigated in this study based on their 2019 values.

Table A2.8: Correlations of self-reported flood exposure data with rainfall

	Flood severity	Flood	Drought	Rain cum	RainMay	RainJune	RainApril
Flood severity	1.00						
Flood	0.97	1.00					
Drought	-0.43	-0.38	1.00				
Rain cum	0.25	0.23	-0.21	1.00			
RainMay	0.22	0.21	-0.20	0.64	1.00		
RainJune	0.06	0.06	-0.06	0.68	-0.02	1.00	
RainApril	0.21	0.20	-0.16	0.64	0.18	0.27	1.00

Table A2.8 displays the bivariate correlation of meteorological precipitation data before and during the 2018 flood and self-reported hazard variables. The rainfall variables indicate Z-scores specifying the monthly deviation of rainfall in April, May and June 2018 from the long-term (1981-present day) mean in the same month in the same location and *rain_cum* adds these over the three-month period. Rainfall data is taken from the high resolution CHIRPS 2.0 – Global Monthly Early Warning Explorer z-score raster with a grid-cell resolution of 0.05 degrees (about 5.5 by 5.5 km grids) (Funk et al., 2014). The table shows that self-reported flood exposure is indeed positively correlated with local rainfall extremes during the relevant months, which provides some evidence that the self-reported data picks up exposure to a weather extreme resulting in floods.

Alternative model specifications

Table A2.9: Alternative dependent variables

Variables	(1) Stealing justified	(2) Disputes
Flood	0.02	0.03
	(0.02)	(0.03)
Constant	0.06***	0.23***
	(0.02)	(0.04)
District FE	Yes	Yes
N	2,028	2,156
R^2	0.06	0.26

*** p<0.01, ** p<0.05, * p<0.1

In alternative models displayed in Table A2.9, we use different plausible alternative dependent variables that capture conflict-related behavior. First, we use *stealing_justified* as dependent variable. Violence in Karamoja may not always be political and conflicts around raiding others' livestock have been frequent (Abrahams, 2021). The variable is worded as follows: *"With what statement do you agree and how much: 1) It is never justified to steal. 2) It can be justified to take others' assets if you or your family go hungry. 3) None of the above. 4) I do not know/do not want to answer"*. An affirmative response to the first option is coded as '1', affirmative response to either two or three as '0', and affirmative response to 4 is set to missing. The two variables violence and stealing justified are positively related (r= 0.15), but not strongly so. In general, much fewer respondents respond affirmatively to this question (violence 13%, stealing 4%). This makes the former more relevant.

As a second alternative dependent variable, we ask respondents whether they had been involved in 'disputes' in the past 12 months. Specifically, we ask about involvement in disputes over land, livestock or water, a rather frequent experience reported by 25% of the respondents in the sample. A notable difference to the other variables is that it is unclear whether respondents themselves have actively started disputes or have been subjected to claims from others. Also, disputes are not necessarily violent and the variable is unrelated to support for violence (r=-0,03).

We find that the coefficients of flood in models of stealing and dispute involvement are positive but not significant. Overall, this suggests that different conflict-related behavior and attitudes follow slightly divergent patterns.

Table A2.10: Full models DID estimation flood impacts on material conditions

Variables	(1) Crop	(2) Livestock	(3) FCS	(4) Wealth index	(5) CSI
Flood	-0.477*	0.0755	3.505***	-0.0428**	-0.291**
	(0.288)	(0.108)	(1.188)	(0.0173)	(0.118)
Time	-1.021*	0.373*	3.739**	-0.156**	0.686***
	(0.580)	(0.221)	(1.828)	(0.0740)	(0.239)
DID	0.677	-0.301**	-2.373	-0.0127	0.684***
	(0.536)	(0.148)	(1.626)	(0.0607)	(0.174)
Pastoralist	0.345***	0.947***	3.196***	-0.00280	-0.169
	(0.128)	(0.111)	(0.755)	(0.0247)	(0.122)
Formal transfers (log)	0.0188	0.117***	0.952**	-0.00338	0.0329
	(0.0562)	(0.0350)	(0.439)	(0.00892)	(0.0616)
Constant	1.807***	0.267***	34.74***	0.184***	2.598***
	(0.367)	(0.0831)	(0.884)	(0.0283)	(0.196)
District FE	Yes	Yes	Yes	Yes	Yes
N	3,930	3,930	3,930	3,930	3,930
R^2	0.068	0.357	0.865	0.164	0.685

Conley standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A2.11: Full models DID estimation flood impacts on subjective conditions

Variables	(1) Absorptive	(2) Transformative	(3) Financial	(4) Political
Flood	0.0302	-0.0691	-0.0759	-0.186**
	(0.0441)	(0.0666)	(0.0680)	(0.0794)
Time	-0.152*	-0.300**	-0.348***	-0.249
	(0.0880)	(0.120)	(0.0758)	(0.152)
DID	-0.104	0.0129	0.0537	0.355***
	(0.101)	(0.0926)	(0.0961)	(0.124)
Pastoralist	0.0314	-0.00775	0.0286	-0.0456
	(0.0757)	(0.0782)	(0.0471)	(0.0641)
Formal transfers (log)	0.00442	0.00180	0.0245	0.00539
	(0.0281)	(0.0230)	(0.0300)	(0.0365)
Constant	2.796***	2.874***	2.186***	2.181***
	(0.0565)	(0.0850)	(0.0563)	(0.110)
District FE	Yes	Yes	Yes	Yes
N	3,929	3,929	3,929	3,930
R^2	0.857	0.872	0.831	0.802

Conley standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A2.12: Flood impacts on transfers received

Variables	(1) Log(Formal transfers pc)	(2) Log(Informal transfers pc)
flood treated	0.216***	-0.0472
	(0.0804)	(0.0385)
time	-0.202***	-0.109**
	(0.0511)	(0.0457)
DID	-0.236***	-0.00176
	(0.0862)	(0.0519)
pastoralist	0.0674	0.0878**
	(0.0487)	(0.0411)
constant	0.283***	0.177***
	(0.0404)	(0.0343)
District FE	Yes	Yes
N	3,930	3,930
R^2	0.152	0.099

Conley standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Plausible confounding factors are among others transfers by development or governmental agencies that may have buffered the flood impact. While we control for formal transfers and thus mitigate any such confounding impacts on our main models, we here in addition specifically estimate flood impacts on formal and informal transfers to the household (per household member) in a difference-in-differences design to further investigate this relationship. Formal transfers received in the last 12 months include for example cash for work or food for work by NGOs, pensions, scholarships, and social initiatives for elderly. Informal transfers include help from family members and in-laws, remittances, gifts and borrowing from friends and relatives. As indicated in Table A2.12, Model 1, we find that flood-affected households received fewer formal transfers compared to others. This result is compatible with the finding that flood exposure was associated with a more negative view on politicians and the government's supportiveness (political capital). In contrast, Model 2 indicates the distribution of informal transfers remained unaffected by flood.

Table A2.13: Material conditions: same respondent sample

Variables	(1) Crop	(2) Livestock	(3) FCS	(4) Wealth index	(5) CSI
Flood treated	-0.315	0.0356	3.368**	-0.0400***	-0.256**
	(0.260)	(0.104)	(1.319)	(0.0137)	(0.121)
Time	-0.865	0.323	3.104**	-0.190***	0.707***
	(0.568)	(0.228)	(1.471)	(0.0670)	(0.234)
DID	0.550	-0.184	-1.816	0.00508	0.614***
	(0.528)	(0.152)	(1.655)	(0.0571)	(0.172)
Pastoralist	0.345***	0.960***	3.165***	-0.0157	-0.126
	(0.109)	(0.109)	(0.724)	(0.0291)	(0.129)
Form.transfers(log)	-0.00335	0.118***	0.966**	-0.0167*	0.0157
	(0.0535)	(0.0400)	(0.473)	(0.00979)	(0.0640)
Constant	1.630***	0.266***	34.71***	0.183***	2.594***
	(0.322)	(0.0834)	(0.841)	(0.0277)	(0.177)
District FE	Yes	Yes	Yes	Yes	Yes
N	3,662	3,662	3,662	3,662	3,662
R^2	0.062	0.335	0.864	0.165	0.681

Conley standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A2.13 mirrors models displayed in Figure 2 in the main manuscript but models are run on an individual-level panel dataset where only individuals interviewed in both rounds are included. Results are substantively close to main models, with the exception of the DID coefficient for flood impacts on livestock, which is no longer significant.

Table A2.14: Subjective conditions: same respondent sample

VARIABLES	(1) Absorptive	(2) Transformative	(3) Financial	(4) Political
Flood treated	0.0140	-0.0757	-0.0577	-0.200***
	(0.0576)	(0.0733)	(0.0718)	(0.0750)
Time	-0.191*	-0.288**	-0.400***	-0.179
	(0.0996)	(0.129)	(0.0792)	(0.163)
DID	-0.0497	0.0430	0.0582	0.358***
	(0.107)	(0.0932)	(0.0968)	(0.116)
Pastoralist	0.0426	0.00928	0.00675	-0.00250
	(0.0690)	(0.0753)	(0.0484)	(0.0659)
Form.transfers(log)	-0.000780	-0.0125	0.0132	-0.0109
	(0.0278)	(0.0266)	(0.0289)	(0.0329)
constant	2.816***	2.880***	2.200***	2.191***
	(0.0524)	(0.0851)	(0.0589)	(0.118)
District FE	Yes	Yes	Yes	Yes
N	3,660	3,661	3,662	3,662
R^2	0.858	0.874	0.831	0.802

Conley standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A2.14 mirrors models displayed in Figure 3 in the main manuscript, but models are run on an individual-level panel dataset where only individuals interviewed in both rounds are included. The results are substantively very similar to main models.

Table A2.15: Multinomial logit alternative coding dependent variable

	MNL1		MNL2		MNL3	
Variables	Support	Neither	Support	Neither	Support	Neither
Flood	0.685***	0.291	0.688***	0.272	0.703***	0.308
	(0.230)	(0.204)	(0.231)	(0.204)	(0.238)	(0.203)
Pastoralist			0.050	-0.296	0.034	-0.303*
			(0.149)	(0.181)	(0.150)	(0.181)
Female			-0.218	-0.170	-0.224	-0.172
			(0.183)	(0.183)	(0.188)	(0.182)
Form.transfers(log)			0.023	0.044	0.011	0.041
			(0.070)	(0.075)	(0.075)	(0.074)
Frought					-0.074	0.259
					(0.195)	(0.217)
FCS					-0.035***	-0.001
					(0.006)	(0.005)
Fatalities (ACLED)					0.692*	-0.184
					(0.417)	(0.737)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-3.327***	-1.380***	-3.170***	-1.166***	-3.207***	-0.910
	(0.429)	(0.302)	(0.478)	(0.347)	(0.974)	(1.445)
N	1,958	1,958	1,958	1,958	1,958	1,958

Standard errors clustered at village level in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

In an alternative set of models displayed in Table A2.15, we use the full range of responses to the 'support for violence' question and run a multinomial logit. We examine three possible responses to the question: *"Which statement do you agree with and how much? The use of violence is never justified in Ugandan politics (reference category, n=1,705); It is sometimes necessary to use violence in support of a just cause ('support', n=253); None of the above ('neither', n=289)"*. As in the main models, we again set the response *I do not know/I do not want to answer (n=198)* to missing. In revising this coding, we acknowledge that '*None of the above*' is substantively different from other responses, though we do not have any clear expectation about how this response should relate to flood exposure. In addition, using a multinomial logistic regression model instead of linear regression is useful for examining the sensitivity of the result to changing assumptions about the functional form of the statistical model.

The results of these tests are in line with the conclusions in the main manuscript. Models MNL1 through MNL3 indicate that flood exposed individuals are significantly more likely to support the use of violence than others.

Table A2.16: Cross section flood impacts – support for violence

Variables	(1) OLS	(2) OLS	(3) OLS	(4) OLS
Change Coping	-0.003			
	(0.040)			
Change Livestock		0.003		
		(0.003)		
Change political capital			-0.025***	
			(0.007)	
Change food consumption				-0.001***
				(0.000)
Pastoralist	0.008	0.009	0.007	0.000
	(0.020)	(0.020)	(0.020)	(0.019)
Female	-0.023	-0.023	-0.021	-0.025
	(0.023)	(0.023)	(0.024)	(0.023)
Log fortransfers	0.001	0.001	0.001	-0.001
	(0.007)	(0.007)	(0.007)	(0.007)
Constant	0.062**	0.062**	0.062**	0.068**
	(0.028)	(0.029)	(0.030)	(0.030)
District FE	yes	yes	yes	yes
N	1,958	1,958	1,958	1,958
R^2	0.189	0.189	0.202	0.196

Conley standard errors in parentheses ***p<0.01, ** p<0.05, * p<0.1

In Table A2.16 we include indicators of change in material and subjective conditions between survey waves in regression models paralleling our main model to gauge whether they are associated in the theorized direction. Given the operationalization as change between the two survey waves the pre-treatment status is accounted for. At the same time, there are factors that may confound the relationships since we no longer rely on natural hazards data that is plausibly exogenous. As a preliminary result, it is noticeable that none of the variables identified as significant flood impacts in the DID analysis is significantly associated with support for violence in the way the theoretical framework outlined. Livestock and use of coping strategies are not significant. A worsening of perception of government supportiveness is associated with less support for political violence. The only factor that is significant and in line with the theoretical framework is food consumption. Here, an improvement of food security is associated with less support for violence.

Chapter 3

What happens to the wellbeing of the left-behind when young adults migrate? A gendered analysis

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Abstract

The migration of individual household members as opposed to en-masse household migration has nuanced effects on the lives of migrants and the well-being of the left-behind family members. This study examines the impact of young household members' migration on the well-being of parents and siblings left behind in rural Bangladeshi households. Exploiting data from the Bangladesh Integrated Household Survey (BIHS) from 2015 and 2018-19 we explore how the migration of sons and daughters affects the nutritional status, schooling, and time allocation of the left behind. This study contributes to the literature on migration and its effects on left-behind household members particularly focusing on the specific gender-differentiated impacts of young household members' migration. By employing an instrumental variable approach we address the endogeneity of migration and provide a robust analysis of these complex relationships. The results suggest that the migration of young household members has multifaceted effects on those left behind. The migration of sons is associated with improved nutritional status for mothers and male siblings likely due to remittances enhancing food availability while no significant impact is observed for fathers. Sons' migration negatively impacts the secondary school attendance rates of left-behind siblings particularly boys who assume increased household responsibilities. Conversely daughters' migration does not significantly affect the nutritional status of parents or siblings nor the latter's school attendance. Furthermore the migration of sons reduces mothers' involvement in domestic work allowing more time for productive and leisure activities whereas daughters' migration increases mothers' domestic workload reducing their leisure time. The findings underscore the importance of considering these gendered repercussions in policy formulation to better support the well-being of families affected by migration. Our study aligns with the broader development objectives and the United Nations Sustainable Development Goals (UN SDGs) emphasizing the need for policies that address the complex dynamics of migration, gender, and family well-being.

JEL Classification: J61; O15; I15; I25; J16; O53

Keywords: Migration; Gender; Wellbeing; Education; Bangladesh

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3.1 Introduction

The migration of individual members of a household as opposed to en-masse household migration affects various aspects of migrants' lives as well as those of the left-behind members including children and parents (Saleemi, 2023). The departure of family members alters household dynamics influencing labor costs and internal structures (Zhunusova and Herrmann, 2018; Mangiavacchi et al., 2018) with ramifications extending to food consumption, education, and resource allocation (Zhang et al., 2015). Notably in densely populated rural contexts like Bangladesh migration can bolster per capita food availability particularly in subsistence farming households while potentially empowering women by redistributing household leadership (Abdulloev et al., 2014; Quisumbing and Maluccio, 2003; Alam, 2012). Remittances from migrant members play a pivotal role enhancing food security and investments in education through in-kind and monetary contributions (Lucas and Stark, 1985). Migrants' exposure to diverse practices abroad can reshape household dynamics and investment priorities albeit with varying effects depending on the specifics of each migration episode (Lee, 2000). Consequently, the absence of remittances may exacerbate negative outcomes highlighting the intricate interplay between migration and household well-being.

Most existing research focuses on the migration of men who leave their wife and family behind (Antman, 2013; Islam and Sharma, 2021; Islam et al., 2019; Rahman et al., 2023) or of parents who leave their children behind (Antman, 2013). Yet many migrants are young adults leaving behind their parents and siblings. The implications of this type of migration may not be the same as for spousal or parental migration as the resulting shifts in household dynamics are different (Antman, 2013, 2010). Yet empirical evidence on the migration of adult children is scarce and scattered. The internal migration of adult children was associated with higher nutrient intake of left-behind parents in rural China (Liu et al., 2021) and in Indonesia (Kuhn et al., 2011). In contrast, international migration has been shown to negatively impact the health of elderly parents left behind in Mexico (Antman, 2013) and revealed no impact in Tonga (Gibson et al., 2011a). We could not find evidence on the effects of adult child migration on the nutrition of siblings left behind nor on the mothers' roles and responsibilities within the household. A few studies consider educational effects (Antman, 2010; Kuhn, 2006; Lu, 2012). found positive effects of adult child migration on siblings' education in Mexico, Bangladesh, and China respectively. This scarce evidence, the effects of the migration of young adults, their left-behind parents, and siblings, and the consequences for intra-household dynamics stands in stark contrast to the widely acknowledged importance of migration in many countries.

This paper contributes to the migration literature by examining the gendered effects of the migration of young household members on the well-being of left-behind individuals in rural Bangladeshi households. We answer the following research questions: *"How does adult child migration impact the nutritional status of their parents and siblings?"*; *"What is the effect of child migration on the school enrollment of their siblings?"*; *"How does the migration influence the time allocation of mothers left behind?"* and lastly *"Do these*

(The Netherlands), November 30^{th} 2023, for their comments on an earlier version on the paper.

effects vary based on the gender of the migrants and their family members?".

We utilize the Bangladesh Integrated Household Survey (BIHS), a nationally representative panel dataset of rural households, which provides valuable information on individuals who migrated between 2015 and 2018-19, as well as on the household members left behind. Estimating the effects of migration is challenging due to the endogeneity of migration. To address this, the study employs an instrumental variable (IV) approach. A commonly used instrument for migration is the proportion of households with a migrant member in the district where the household resides (Jabbar, 2022; Antman, 2013; Atamanov and Van den Berg, 2012; Gray and Bilsborrow, 2014; McKenzie and Rapoport, 2011; Nam and Portes, 2023; Veljanoska, 2022; Zhao and Chen, 2022). The study applies a two-stage least squares (2SLS) panel model with household fixed effects, as used by Saleemi (2023), along with robust standard errors.

Bangladesh provides an interesting setting to study this topic since the country has ranked sixth among the top 20 countries of origin for international migrants with a total of 7.5 million (4%) Bangladeshis living abroad (IOM, 2021). Internal migration is even more prominent as 80% of the migrants in the BIHS stayed within Bangladesh. In addition, rural Bangladesh has a long history of food insecurity, low school attendance, and gender disparities. No less than 33% of the Bangladeshi population suffers moderate-to-severe food insecurity (both among adults and children) (FAO, 2021). Additionally, around 38 percent of secondary school students dropped out in 2016 (Sarker et al., 2019). Whereas primary education is a constitutional obligation, secondary education is not free and compulsory. Thus, at this stage, students and their families face a choice between continuing school or joining the labour force. Lastly, Bangladesh is an example of a patriarchal society with strict gender roles where women are often confined to the domestic sphere with limited control over income and resources, limited mobility outside their home, and limited decision-making power within the household (Malapit et al., 2019; Schuler and Rottach, 2010; Sraboni et al., 2014). This patriarchal nature of society also shapes the gendered pattern of migration and remittances (King Kilinch 2012) Men migrate mainly for employment and are likely to send remittances whereas women move mainly for marriage and are less likely to send remittances gender (Rahman and Sheema, 2021; Mannan and Farhana, 2014). These different forms of migration may have different consequences for those left behind. Also, the shift in within-household dynamics may depend on the gender of the migrant (Islam and Sharma, 2021; Islam et al., 2019).

Our results show that migration of young household members has multifaceted effects on those left behind. Specifically, the migration of sons influences the nutrition, education, and daily activities of their parents and siblings. More specifically, sons' migration results in improved nutritional status for their mothers and brothers. This improvement is likely facilitated by remittances, which are often directed towards food consumption (Nath and Mamun, 2010; Kumar et al., 2018). A downside of son migration is a decreased secondary school attendance for boys left behind possibly due to their increased involvement in household duties previously handled by the migrant son (Jabbar, 2022) This phenomenon aligns with existing research indicating that siblings of migrants, particularly older ones, may be more inclined to skip school to assist with household chores, especially in rural settings where agriculture is a primary source of livelihood (Admassie, 2003).

Moreover, the impact extends beyond nutritional and educational aspects to the daily activities of left-behind mothers. Sons' migration prompts a notable shift in mothers' time allocation characterized by reduced involvement in domestic work and increased engagement in productive activities and leisure pursuits. Conversely, the migration of daughters appears to have a different effect on mothers, leading to a reduction in leisure time as mothers assume tasks previously undertaken by their migrated daughters. This disparity underscores prevailing gender roles within households with women often bearing the brunt of domestic responsibilities, particularly in contexts where female members migrate (Bandiyono, 2016).

Overall, these findings underscore the intricate interplay between migration, family dynamics, and socio-economic factors. They highlight the need for nuanced approaches to understand and address the diverse impacts of migration on left-behind families, taking into account gender dynamics, socio-economic conditions, and cultural contexts. By elucidating these complexities, policymakers and practitioners can develop targeted interventions aimed at mitigating potential adverse effects while harnessing the positive aspects of migration for the well-being and empowerment of all family members left behind.

The remainder of this paper is structured as follows: Section 2 provides an overview of the conceptual framework, Section 3 explains the data and methodology used in the study, Section 4 outlines the results, and Section 5 discusses conclusions and implications.

3.2 Conceptual framework: Migration and the left-behind

Researchers have extensively studied the reasons why people migrate and the impacts on the areas they move to. They have also explored the effects of migration on the people that are left behind in the origin area. Within this scope, recent research has examined how family separation impacts individuals who remain behind. Several papers have investigated how a family member's migration affects the wellbeing of the parents and children left at home, though there is no clear consensus on the extent and direction of these impacts (Biavaschi et al., 2015).

The migration of a household member can have complex effects on those left behind with both positive and negative outcomes. The specific effects of migration can vary depending on factors such as the relationship between the migrant and the left-behind members, the division of resources, and the remittance status (Bennett et al., 2012). It is important to consider these factors when assessing the impact of migration on households.

Individual migration and left-behind household dynamics are interconnected: migration decisions are shaped by and in turn shape the economic, physical, and emotional well-being of the other members (Biavaschi et al., 2015; Haider et al., 2017; Nasreen Abbasi et al., 1983; Niken Kusumawardhani and N. Warda, 2013). The migration of a member could have different implications for the household members left-behind as it shapes their resources availability and household dynamics (Nasreen Abbasi et al., 1983).

Table 3.1: Mechanisms linking individual migration to left-behinds' outcomes

Individual Migration	Left-behind household members: · Lower contribution to domestic and income-generating work ("lost-labour" effect) $\rightarrow education(-), timework(+)$ · Less resources required to sustain hh members ("proximity" effect) $\rightarrow Morefoodp.c.available \rightarrow nutrition(+)$ Remittances (liquidity, insurance) ("income" effect) $\rightarrow nutrition(+), education(+)$	Outcomes: 1. Nutrition 2. Education 3. Time use

When a member migrates, firstly, the household has fewer people to feed, hence the left-behind members have more food per capita available (Amina Maharjan et al., 2010). Secondly, there are fewer people who potentially work, contributing to household income, and fewer people contributing to household work (Gibson et al., 2011a,b; Xu, 2017). This could cause a redistribution of work and resources among the left-behind as they may increase their contribution to domestic work and to productive work through income-earning activities (Agasty, 2016; Khan et al., 2016; Phadera, 2019). This could have negative consequences, especially for children and mothers left behind. Children may experience lower school attendance and educational attainments (Antman, 2013; Giannelli and Mangiavacchi, 2010; Hu, 2012; Marchetta et al., 2021; Morooka and Liang, 2009; Zhou et al., 2014). Instead, women, particularly mothers, could become overburdened due to increased work and responsibilities and ultimately be left with little time for personal care or leisure activities (Phadera, 2019; Rahman et al., 2023). At the same time, when a member leaves the household, fewer resources are needed to care for the remaining members overall, including less time spent by the mother to care for other members (Sathar and Kazi, 2000; Ross, 2006).

Thirdly, the migrant member, however, may send remittances to the left-behind. The remittances can play a significant role. They can increase household's liquidity – which can result in increased food consumption (Harris-Fry et al., 2017; Moniruzzaman, 2020), education (Yang, 2008), and overall socioeconomic status (Elie Murard, 2014; Haider et al., 2017) and they can serve as an income insurance against potential adverse shocks (Taylor and Martin, 2001). Conversely, in the absence of remittances, the household left-behind could observe a decline in income and wellbeing (Bennett et al., 2012; Murard, 2019) as the negative effects of migration would prevail.

For Bangladesh, previous research has found positive relations between international migration and the wellbeing of the left behind members. Households with international migrant members experienced higher asset scores, lower food expenditure share, and improved welfare (Ahmed, 2022; Hadi, 1999). In terms of food and nutrition security, international migration has been found to have a positive impact on the quantity, quality, and variety of food consumed by left-behind households (Romano and Traverso 2020, 2019). (Hassan and Jebin 2020)(Romano and Traverso, 2020, 2019) emphasized the positive impact of men's international migration on the empowerment of their wives. However, these studies only focus on international migration and consider either only migration of the husband/father or do not distinguish migrants based on their position in the household.

3.2.1 Migration of adult child

Parents are not the only members who can migrate. Younger members of the household, such as the sons and daughters, may migrate too. Although evidence on their migration is scarce, the implications for the members left behind may differ from those related to parental migration. In particular, the changes in household dynamics will be different which may affect how the wellbeing of those left behind changes (Antman, 2013, 2010). Yet much of the existing research has focused on the experiences of children whose parents migrate and leave them behind (Antman, 2013).

Research on the impact of migration of adult children on the well-being of their parents left-behind presents mixed findings and is still limited to a few countries. On one hand, the increased income from migrant's remittances may give families better access to resources that improve health and welfare. For instance, internal migration in Indonesia had a positive effect on elderly parents (Kuhn et al., 2011) and daughter's migration had a positive impact of on parents' health and life satisfaction (Wahba and Wang, 2019). Conversely, the migration of working-age children can disrupt traditional family care arrangements and the distribution of responsibilities, which might reduce the welfare of elderly parents left behind. The international migration from Mexico to the US has been shown to negatively impact the health of elderly individuals left behind (Antman, 2013). Also in Nepal (Ghimire et al., 2018) found that having a migrant child was associated with increased risks of self-reported chronic diseases, depressive symptoms, and perceived loneliness among elderly parents. Instead, international migration from Tonga revealed no impact on the health of elderly household members (Gibson et al., 2011a). In conclusion, the impact of child migration on the well-being of elderly parents seems to vary depending on the context and the specific indicators of well-being being measured.

While to our knowledge there is no previous evidence studying the impact of child migration on the nutrition of siblings left behind, there is limited empirical evidence on the impact of migration on siblings staying behind. In India, siblings left behind by rural-urban migrants showed lower school attendance, continuation in education, and educational attainment (Agasty, 2016; Antman, 2010; Lu, 2012) both found positive effects of adult child migration on siblings' education, particularly for girls in Mexico and China. For the Matlab region in Bangladesh (Kuhn, 2006) found that son but not daughter migration had a positive and significant effect on left behind siblings' pace of schooling. They argue that this reflects the more important role of male kin in providing familial support. The effects are stronger when the migrant moves abroad (international migration). The latter study used data for Bangladesh and had a limited geographic coverage, and it is therefore worthwhile to explore the implication of sons' (and daughter) migration for the school attendance of the left-behind siblings through more recent national panel data.

This mixed evidence results from the various forces at play when young adults migrate and leave their siblings behind. On the one hand, migration may entail a flow of remittances that could be invested in siblings' education and nutrition. On the other hand, children may skip school to contribute to household or farm work, causing a decrease in academic performance (Jabbar, 2022). Additionally, siblings can influence each other in several ways. Siblings may serve as role models (Haynie and McHugh, 2003) and they might directly shape each other's outcomes by providing socialization opportunities or impacting (younger) siblings' personality and intelligence (Arnold et al., 1975). Economists have found that older siblings can affect younger siblings' high school graduation rates (Oettinger, 2000; Rees and Sabia, 2009) and risk-taking behaviors (Altonji et al., 2017). It is reasonable to expect that sibling interactions could play a unique or even more significant role during the absence of siblings, particularly in the case of migration (Biavaschi et al., 2015). In fact, given that older siblings have an influence on younger siblings, the education attainment of the older can partially explain the attainment of the younger sibling (Yu and Yan, 2023).

3.3 Data & Methodology

3.3.1 Data

To empirically assess the impact of young adults' migration on the left behind parents and children, we analyze the Bangladesh Integrated Household Survey (BIHS). This is a nationally-representative panel dataset of rural households collected by the International Food Policy Research Institute (IFPRI), which contains detailed information on migrated members, anthropometric measures, women's empowerment, and socio-economic characteristics. The BIHS was collected in three rounds: October 2011-June 2012, January-May 2015, and November 2018-April 2019. For our research, we mainly use the latter two rounds. Specifically, we focus on the effects of migration between those rounds ("recent migration") on 2018-2019 outcomes.

The share of households in the survey with at least one recent migrant was 25% (n=1147) in 2018-2019 with a recent migrant defined as person that was a member of the household during 2015 survey round but has been living away for six months or more within the country but not in the same Upazilla (sub-district) or abroad. The migrated individuals were typically adult children of household heads rather than the household heads themselves. 74% of households with migrants (n=843) had a migrated son or daughter or both. We focus on these households and compare them with households that never reported a migrant member in either of the survey rounds (around 12 years). Differentiating by gender of migrants, this gives four (partly overlapping) groups of households: Migrant Son households (n=474), Migrant Daughter households (n=324), Migrant Child households (any gender n=641), and Non-migrant households (n=2657).

3.3.2 Estimation strategy

To assess the impact of child migration on the wellbeing of household members left-behind, we estimate the following equation:

$$Y_{it} = \alpha_i + \alpha_1 M_{it} + \alpha_2 X_{it} + \epsilon_{it} \tag{3.1}$$

where Y is a vector of outcome indicators, M is a dummy for migration of a child, and X is a vector of variables to control for household characteristics.

Our outcome variables represent individual characteristics on nutrition, school attendance, and time use of the members left-behind. Nutrition is measured as dummies for being underweight (BMI < cutoff, see Table 3.5 for details and cutoff values) for the parents of the migrant (mother, father) and the children/siblings (age 6-18). Education is measured by binary variables for secondary school attendance during the previous year for household members aged 11-18 years who went to school during the previous year. We focus on the attendance rate of secondary school because primary school attendance was almost universal (Table 3.3). For time use, we consider the minutes spent on daily activities by the main female household respondent. We categorize the activities in four main groups according to their scope: Domestic work, Productive work, Personal time, Leisure time (Table 3.2).

Table 3.2: Time (minutes) per day spent by mother on activities

Category	**Activity**
Domestic work	Shopping/getting service; Cooking; Domestic work; Care for children/adults/elderly
Productive work time	Work as employed; Own business work; Farming; Construction; Fishing; Weaving, sewing, textile care; Commuting
Leisure time	Watching TV/listening to radio; Reading; Sitting with family; Exercising; Social activities; Practicing hobbies; Religious activities
Personal time	Sleeping and resting; Eating and drinking; Personal care

We control for household wealth and size, the presence of a male child, and the month of interview (Gibson et al., 2011b). The wealth of the household is calculated as an index through principal-component factor analysis. The household size is equal to the number of household members that are living in the same household. The presence of male child is equal to 1 if at least one child lives in the household. The month of interview is included as a covariate to account for seasonality effects. We additionally sub-sample our analysis by differentiating on the gender of child/sibling left behind.

In a second specification, we distinguish between the effects of male (M^m) and female child migration (M^f) to disentangle the gendered effects of migration:

$$Y_{it} = \alpha_i' + \alpha_1^m M_{it}^m + \alpha_1^f M_{it}^f + \alpha_2' X_{it} + \epsilon_{it}' \tag{3.2}$$

As migration is endogenous due to the self-selection of migrants and migrant households, we use an instrumental variable approach to generate unbiased estimates (Angrist and Pischke, 2009; McKenzie and Sasin, 2007). The instruments we use reflect the share of households with a migrant member (as defined above) in the district of household residence. This results in three instruments: the district share of households with a child migrant for equation 1 and the district share of households with a male child migrant and the district share of households with a female child migrant for equation 2. This instrument was previously used by many scholars (Jabbar, 2022; Antman, 2013; Atamanov and Van den Berg, 2012; Gray and Bilsborrow, 2014; Hildebrandt et al., 2005; McKenzie and Rapoport, 2011; Nam and Portes, 2023; Veljanoska, 2022; Zhao and Chen, 2022). This variable reflects migration networks which contribute to increases in migration opportunities and to reductions in migration costs in the district (Zhao and Jiang, 2022; Taylor et al., 2003) and is therefore correlated with the migration decisions of individual households but has no direct effect on their wellbeing.

We estimate equations (1) and (2) using 2SLS regression with household fixed effects (as used by Saleemi (2023)) and robust standard errors. We use logit regression to estimate the first stage. To test the equality of regression coefficients for male and female migrants we conduct a Lincom test. This is a post-estimation test that measures if the difference between the estimated coefficient of "migrant son" and "migrant daughter" are significantly different. As a robustness check in the appendix Tables A3.9-A3.22 we present the full set of model results starting with the standard Fixed Effects (FE) model. We then sequentially add controls to the FE model. Following this, we estimate the Two-Stage Least Squares (2SLS) model without controls and finally, we add controls to the 2SLS model. The final model, which includes the 2SLS estimation with controls, is reported in the main text.

3.3.3 Descriptives

Table 3.3 shows the difference in means of the main individual and household characteristics between migrant and non-migrant households before migration. Migrant and non-migrant households have similar levels of nutrition, primary school attendance, and time use of women. Children were better nourished than their parents: around 20% of children are underweight compared to around 30% of parents. Almost all children of primary school-age attended school, which is compulsory and free. Women allocate most of their time to personal time and domestic work. Secondary school attendance was lower for migrant households, 83% vs 87%. Furthermore, migrant households tended to be composed of more members and to own more assets than non-migrant households.

Table 3.3: Before-migration differences between households with and without young members migrating

Variable	Mean No-migrant	Mean Migrant	Diff	p-value
Underweight child	0.226	0.205	0.022	0.146
Underweight mother	0.326	0.330	-0.004	0.892
Underweight father	0.337	0.329	0.008	0.762
Primary school attendance	0.995	0.992	0.003	0.554
Secondary school attendance	0.874	0.829	0.045***	0.004
Personal time	721.991	717.532	4.460	0.439
Leisure time	197.845	203.605	-5.760	0.338
Domestic work time	417.792	420.870	-3.078	0.679
Productive work time	118.731	119.130	-0.399	0.953
Household size	4.488	5.258	-0.769***	0.000
Wealth index	0.161	0.184	-0.025***	0.000
Male child	0.003	0.002	0.002	0.527
Month of interview	3.743	3.774	-0.031	0.548

Table 3.4 reports the mean differences between households with a migrant son and households with a migrant daughter before migration. Children in households with migrant sons were less likely to attend secondary school than children in households with migrant daughters. Additionally, the time allocation

of the mother differed by gender of the migrant. The time spent on domestic work was higher for mothers of migrant sons. The pre-migration time spent by the mother on productive work was instead higher in households with migrant daughters.

Table 3.4: Before migration differences of treated units, by migrants' gender

Variable	Mean daughter	Mean son	Diff	p-value
Underweight child	0.176	0.214	-0.039	0.157
Underweight mother	0.275	0.355	-0.081	0.172
Underweight father	0.314	0.340	-0.026	0.650
Primary school attendance	0.992	0.990	0.003	0.840
Secondary school attendance	0.864	0.806	0.058**	0.060
Personal time	725.775	710.496	15.280	0.188
Leisure time	191.391	207.397	-16.006	0.176
Domestic work time	404.519	430.248	-25.729**	0.097
Productive work time	148.797	107.273	41.524***	0.004
Household size	5.218	5.104	0.114	0.444
Wealth index	0.174	0.190	-0.015**	0.089
Male child	0.000	0.003	-0.003	0.474
Month of interview	3.851	3.737	0.114	0.301

Note: 88 households with both migrant son and daughter are excluded from this table (but included in Table 3.3).

Table 3.5 provides descriptive statistics for key characteristics of the migrants by gender. Most migrants stay within Bangladesh. They were young, 21 and 20 years on average for sons and daughters respectively, and left on average 26 (sons) and 22 (daughters) months before the survey. While most migrants completed at least primary education, daughters were more likely to be educated than sons. A striking gender difference stands from the purpose of migration. Sons migrate mostly to find employment, whereas daughters migrate for reasons related to marriage – in Bangladesh, the practice of women moving to their husband's home after marriage is still common, despite constitutional provisions for equal rights (D. Hollander, 2007; Nusrat Ameen, 1997). Also the likelihood of sending remittances vary significantly by the migrant's gender. Most migrant sons send remittances to their family, whereas relatively few of the migrated daughters do 67% and 32%, respectively. This is likely correlated with the motive of migration. As noted by (Nath and Mamun, 2010), especially migrants who leave for employment send remittances.

3.4 Results

In this section, we report and discuss our results. Tables 3.6-3.8 report the 2nd stage of the 2SLS model (equations 3.1 and 3.2). The estimation results suggest significant effects of the migration of any adult child on the left-behind parents and siblings. It improves the wellbeing of mothers and siblings left behind by decreasing their underweight rate, and it decreases the secondary school attendance rate. Additionally, the results suggest highly heterogeneous effects depending on both the migrants' and the left-behind's gender. It appears that the migration of sons is what drives the effects. In fact, son's migration has significant consequences on the left-behind members in line with the results obtained from the overall migration estimates. These general considerations on the results are valid for the estimates

Table 3.5: Descriptives of migration by migrant gender

Variable	Child	Son	Daughter	Diff Son-Dau	p-value
Purpose of migration (%)					
Employment	61%	75%	26%	-0.479***	0
Education	19%	20%	17%	-0.016	0.64
Marriage	27%	8%	65%	0.565***	0
Duration of migration (months)	22.38	26.09	21.97	4.113***	0
Sends remittances	51%	67%	32%	-0.481***	0
Education of migrant (%)					
No education	19%	23%	11%	-0.089***	0.01
Primary education	39%	39%	45%	0.072*	0.10
Secondary education	42%	38%	44%	0.038	0.25
Age of migrant (years)	20.50	21	19	-2.089***	0
Internal migration	81%	98%	86%	0.223	0

Note: The last two columns provide the difference between the migrant sons and daughters samples, and the corresponding t-value. *** p<0.01, ** p<0.05, * p<0.1.

concerning all the outcomes of interest, namely wellbeing, education, and time use.

Additionally, our instruments are strong, relevant, and valid as reported in the first stage coefficients in **Tables A3.9-A3.18**.

3.4.1 Underweight

Table 3.6 summarizes the impact of migration on the nutritional status of left behind family members. While fathers' nutritional status is not affected, mothers and siblings are less likely to be underweight in households with a migrant, at least when the migrant is male, although the gendered difference is only statistically significant for the mothers. These results are in line with findings of (Kuhn et al., 2011), who find positive effects of child migration on parental health in Indonesia. Our results indicate that food consumption of mothers responds more to changes in income and food availability than that of fathers. This supports existing evidence of higher elasticity of consumption for women's goods and services compared to men's. The results for brothers and sisters are less conclusive of gendered differences in elasticities.

As discussed before, sons migrate mainly for employment and are more likely to send remittances than daughters who migrate mainly for marriage (Nath and Mamun, 2010). The decrease in undernutrition rates that we observe suggests that at least part of the remittances are channeled into food consumption (Kumar et al., 2018; Raihan et al., 2009). This is in accordance with earlier findings for other countries that remittances improve nutrition (Zingwe et al., 2023), food security and calorie supply (Thow et al., 2016), and are used to invest in higher quality nutrients (B. Langworthy, 2011; Isoto and Kraybill, 2017).

3.4.2 Education

Table 3.7 lists the effects of migration of young adults on the secondary education of their siblings. Boys are less likely to attend secondary school when an older brother migrates. We found no such effects

Table 3.6: 2SLS regression results: Effect of migration on the likelihood of being underweight

Variable	Mother	Father	Sibling	Brother	Sister
Migrant Child	-0.312**	-0.114	-0.209***	-0.191*	-0.223**
	(0.110)	(0.074)	(0.054)	(0.085)	(0.068)
Migrant Son	-1.046**	-0.135	-0.413*	-0.500*	-0.348
	(0.355)	(0.132)	(0.187)	(0.216)	(0.313)
Migrant Daughter	0.315	-0.042	0.099	0.088	0.084
	(0.376)	(0.160)	(0.197)	(0.212)	(0.366)
Diff (Lincom)	-1.361*	-0.093	-0.513	-0.587	-0.432
S.E.	(0.702)	(0.270)	(0.375)	(0.408)	(0.671)

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

for girls or older sisters. In rural settings where households' main livelihood comes from agriculture, many children skip school to help with household farm or domestic work (Admassie, 2003). These findings contrast (Kuhn, 2006), who finds positive effects of son migration on the pace of schooling of the siblings left behind in the Matlab region of Bangladesh in 1996. These effects were especially strong for international migration.

In our case, the younger brothers left behind seem to substitute the migrant's work, decreasing their school attendance. Possible remittances seem to be used for households' primary needs such as food consumption rather than to support education of younger siblings. The younger boys may also mirror the behavior of their older brothers (Yu and Yan, 2023). Many of the male migrants in our sample did not finish secondary school or even primary school, and in Bangladesh, rural migrants often work in the informal economy primarily in low-paying unskilled productive work such as construction and rickshaw pulling which does not require formal education (Hasan, 2019; Islam et al., 2019; K. Farhana, 2011).

Table 3.7: 2SLS regression results: Effect of migration on education of left-behind siblings

Variable	Sibling	Brother	Sister
Migrant Child	-0.203**	-0.307**	-0.142
	(0.066)	(0.115)	(0.076)
Migrant Son	-0.491**	-0.750***	-0.168
	(0.152)	(0.228)	(0.191)
Migrant Daughter	0.170	0.200	-0.040
	(0.175)	(0.240)	(0.221)
Diff (Lincom)	-0.661**	-0.951**	-0.128
S.E.	(0.304)	(0.396)	(0.396)

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.4.3 Time use

The estimation results in Table 3.8 indicate that the time employed by the left-behind mother in daily activities is significantly affected by the migration of one of her adult children. When their son migrates, mothers decrease the time spent on domestic work and personal care while they increase time spent on leisure and productive work. Conversely, the migration of the daughter decreases her mother's leisure time. These gendered differences can be explained by the strong gender roles in Bangladesh where the women of the household share the responsibility for the domestic work. Our results suggest that while adult daughters relieve some of their mothers' duties, adult sons rather cause additional domestic work.

By disentangling the effects of each daily activity, we understand more about how the mother left-behind re-allocates her time in the aftermaths of her son or daughter's migration. Specifically, from Table 3.8 we observe that the migration of any adult child (son or daughter) decreases the mother's time spent on eating and drinking. Instead, she spends a bit more time on personal care. After a son's migration, she spends a lot less time on caring for others, which frees up time for farming, traveling, watching TV, and especially social activities. When it comes to daughter's migration, the mother reallocates her time very differently. She decreases time on traveling, watching TV, and participating in social activities to practice more religious activities.

These results suggest that in terms of time allocation, women benefit from migration of a son but not from migration of a daughter. Women's increased involvement in productive activities and thus increased contribution to income generating activities could be beneficial for her empowerment and consequently for her and her household wellbeing (Jayaraman and Findeis, 2012). When women provide higher economic contributions to the household, this can increase their control over the household earnings (Khan, 1999) and can lead to a redistribution of household chores and leisure activities (Malema and Naidoo, 2017). This favors a balanced resource distribution within the household, including food allocation, contributing to the improvement of mother and child nutrition (Jayaraman and Findeis, 2012).

Table 3.8: 2SLS Regression results: Effect of migration on time use of left-behind mothers

Variable	Domestic work	Productive work	Personal time	Leisure
Migrant Child	-100.675***	42.368*	-32.288	68.428***
	(23.829)	(17.911)	(17.234)	(18.163)
Migrant Son	-192.284**	95.903*	-109.315*	313.130***
	(59.139)	(44.279)	(46.135)	(58.812)
Migrant Daughter	22.297	-22.496	31.390	-153.991**
	(63.028)	(44.788)	(46.267)	(58.573)
Diff (Lincom)	-214.581*	118.399	-140.705	467.121***
S.E.	(116.152)	(84.230)	(87.694)	(111.696)

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Robustness checks

We re-estimate the causal effect of migration on wellbeing and schooling using regular 2SLS regression (with OLS as first stage) as an alternative to the two-step IV regressions (with logit at first stage) Tables A3.23-A3.34). The results confirm the robustness of our findings.

3.5 Conclusions

This paper contributes to the migration literature by analyzing the linkages between adult child migration and the well-being of left-behind household members, which has so far received little scrutiny. We begin by estimating the overall impact of child migration on the left-behind parents and siblings in terms of being underweight, school attendance, and the time use of mothers. Next, we deepen our insights by disentangling the effects by the gender of the migrant and the gender of the left-behind.

The results suggest that the migration of adult children affects the left-behind parents and siblings in different ways. It improves the well-being of the remaining household members by decreasing the underweight rates of mothers and children and increasing leisure time of mothers, but also leads to a decrease in secondary school attendance rates of boys.

We also observe that the effects vary depending on the gender of the migrant and the left-behind members. The effects on nutrition are mainly caused by the male migrants who are more likely to send remittances than the female migrants. Similarly, only male migration reduced school attendance and only for boys. The improved nutrition is likely a result of remittances supporting food consumption, confirming that internal remittances positively impacted farm households (Akhter et al., 2022) while the decrease in school attendance is possibly due to a loss of labor (Jabbar, 2022). The effects of migration on the mother's time allocation also depends on the gender of the migrant, with son's migration leading mothers to shift from domestic work and personal care to productive work and leisure. Conversely, daughters' migration decreases mothers' leisure time as they take on tasks previously handled by the migrated daughters (Bandiyono, 2016).

Hence, other than for time allocation, only male migration affected the wellbeing of those left behind. These findings are in line with previous research (Kuhn, 2006) and highlight the more important role of male kin in providing familial support. According to Lee (2000) "The greater importance of male out-migration in this context and the more important role of male kin in providing familial support in general suggest that brothers' migration will have a greater impact than sisters". Work in other societies with a history of patrilineal family norms has typically found that these norms persist in the context of migration. Given that most of the male migrants moved for employment, our results also highlight the role of occupational mobility in enhancing well-being, confirming previous findings (Mannan and Farhana, 2014).

We acknowledge that our study has limitations that should be taken into account when interpreting our results and their implications. Caution should be exercised when applying our findings to broader or different contexts. Future research could build upon our work by exploring the following areas: Firstly, analyzing the effect of sibling migration on additional outcomes such as the nutritional status of children (siblings) under 5 years. Although the BIHS dataset provides the necessary anthropometric measures to calculate stunting, wasting, and underweight scores, the timing of the survey rounds (every 4 years) did not allow us to create a panel dataset of children under 5 years of age with enough observations for analysis. Therefore, we left this analysis for future research. Secondly, selecting the non-migrant group through matching techniques (such as Coarsened-exact matching or Propensity score matching) to allow comparison between treated and untreated households based on similar pre-treatment characteristics. Thirdly, understanding if the changes in women's time use in the aftermath of migration translate into changed well-being for women and children primarily and for husbands (i.e. through a structural equation model or causal mediation analysis). Fourthly, to assess the external validity of the findings, this analysis could be replicated in different rural areas as well as in diverse urban contexts. This approach would enable us to determine whether the results remain consistent across populations with similar or varying socio-economic and cultural characteristics.

The impact of young members' migration on the well-being of the family members they leave behind is a critical consideration for policymakers. The effects of individual migration should be factored into the agendas of international organizations and governments. Additionally, the well-being implications should guide discussions on migration and development. Accounting for the effects of migration on nutrition, education, and empowerment can contribute to the creation of more effective policies aimed at achieving the UN Sustainable Development Goals (SDGs): UN-SDG 2 (Zero Hunger), UN-SDG 3 (Good Health and Well-being), UN-SDG 4 (Quality Education), and UN-SDG 5 (Gender Equality). Policy interventions should aim to minimize any disruptions to the relationship between migrants and their households of origin, as these disruptions could undermine the potential benefits of migration. Such measures might include creating avenues for regular communication, ensuring access to remittances, and supporting the integration of migrants into their new communities while maintaining connections to their families back home. By doing so, policymakers can enhance the positive effects of migration on the well-being of left-behind family members and work toward achieving broader development goals.

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Appendix

	WHO (BMI)	**Asia-Pacific (BMI)**
Underweight	<18.5	**<18.5**
Normal	18.5–24.9	**18.5–22.9**
Overweight	25–29.9	**23–24.9**
Obese	≥30	**≥25**

To measure "underweight" for boys and girls aged >5 and <19, we compare their BMI with the WHO BMI-for-age growth charts , which are different for boys and girls and offer age- and sex-specific percentiles. By referring to these charts, we can determine where the child's BMI falls relative to the population of children of the same age and sex. If the child's BMI-for-age is less than -2 standard deviations (SD) from the median on the growth chart, the child is classified as thin or "underweight". This process ensures that BMI and thinness are evaluated in a standardized manner, considering the natural variations in growth patterns between boys and girls.

Table A3.1: Descriptive Statistics for households with Migrant Sons (t=2015 and t=2018-19)

	N	Mean	SD	Min	Max
Migrant Son (t=2015)					
Underweight sibling	764	0.21	0.41	0	1
Underweight mother	216	0.34	0.48	0	1
Underweight father	284	0.34	0.47	0	1
School attendance	1125	0.73	0.44	0	1
Primary school attendance	253	0.99	0.09	0	1
Secondary school attendance	523	0.8	0.4	0	1
Personal time	472	712.75	129.76	360	1290
Leisure time	472	207.9	126.16	0	675
Domestic work time	472	427.72	169.26	0	960
Wage work time	472	108.65	139.9	0	900
Household size	474	5.27	1.6	2	13
Wealth index	474	0.19	0.11	0.02	0.66
Migrant Son (t=2018-19)					
Underweight sibling	485	0.12	0.33	0	1
Underweight mother	158	0.27	0.45	0	1
Underweight father	267	0.31	0.47	0	1
School attendance	774	0.74	0.44	0	1
Primary school attendance	176	1	0	1	1
Secondary school attendance	347	0.83	0.37	0	1
Personal time	471	721.18	127.62	420	1320
Leisure time	471	264.39	147.22	0	945
Domestic work time	471	368.09	160.04	0	855
Wage work time	471	117.17	135.65	0	795
Household size	474	5.87	1.95	2	18
Wealth index	474	0.2	0.1	0.02	0.7

Table A3.2: Descriptive Statistics for households with Migrant Daughter (t=2015 and t=2018-19)

	N	Mean	SD	Min	Max
Migrant Daughter (t=2015)					
Underweight sibling	595	0.19	0.39	0	1
Underweight mother	151	0.29	0.46	0	1
Underweight father	189	0.32	0.47	0	1
School attendance	837	0.78	0.41	0	1
Primary school attendance	199	0.99	0.1	0	1
Secondary school attendance	414	0.85	0.35	0	1
Personal time	322	726.61	132.37	345	1320
Leisure time	322	208.04	135.21	0	720
Domestic work time	322	402.9	182.6	0	945
Wage work time	322	131.51	177.84	0	870
Household size	324	5.52	1.77	2	14
Wealth index	324	0.18	0.1	0.02	0.66
Migrant Daughter (t=2018-19)					
Underweight sibling	352	0.14	0.35	0	1
Underweight mother	133	0.22	0.41	0	1
Underweight father	169	0.3	0.46	0	1
School attendance	559	0.77	0.42	0	1
Primary school attendance	138	1	0	1	1
Secondary school attendance	257	0.84	0.36	0	1
Personal time	318	723.58	129.05	435	1290
Leisure time	318	261.37	144.65	0	735
Domestic work time	318	380.52	174.25	0	915
Wage work time	318	105.09	127.71	0	825
Household size	324	6.05	2.03	2	17
Wealth index	324	0.19	0.09	0.03	0.53

Table A3.3: Descriptive Statistics for households with Migrant Child (t=2015 and t=2018-19)

	N	Mean	SD	Min	Max
Migrant Child (t=2015)					
Underweight sibling	1071	0.2	0.4	0	1
Underweight mother	303	0.33	0.47	0	1
Underweight father	374	0.33	0.47	0	1
School attendance	1546	0.77	0.42	0	1
Primary school attendance	367	0.99	0.09	0	1
Secondary school attendance	749	0.83	0.38	0	1
Personal time	638	717.53	131.09	345	1320
Leisure time	638	203.61	129.43	0	720
Domestic work time	638	420.87	173.58	0	960
Wage work time	638	119.13	156.87	0	900
Household size	641	5.26	1.66	2	14
Wealth index	641	0.18	0.1	0.02	0.66
Migrant Child (t=2018-19)					
Underweight sibling	691	0.13	0.34	0	1
Underweight mother	233	0.25	0.43	0	1
Underweight father	355	0.32	0.47	0	1
School attendance	1097	0.76	0.43	0	1
Primary school attendance	266	1	0	1	1
Secondary school attendance	492	0.84	0.37	0	1
Personal time	634	723.88	124.74	420	1320
Leisure time	634	257.34	145.03	0	945
Domestic work time	634	374.2	162.95	0	915
Wage work time	634	116.12	135.09	0	795
Household size	641	5.81	1.96	2	18
Wealth index	641	0.2	0.09	0.02	0.7

Table A3.4: Descriptive Statistics for households with No-Migrants (t=2015 and t=2018-19)

	N	Mean	SD	Min	Max
No-migrant t=2015					
Underweight child	3055	0.23	0.42	0	1
Underweight mother	1356	0.33	0.47	0	1
Underweight father	1819	0.34	0.47	0	1
School attendance	4213	0.78	0.41	0	1
Primary school attendance	1455	0.99	0.07	0	1
Secondary school attendance	1635	0.87	0.33	0	1
Personal time	2636	721.99	130.57	225	1440
Leisure time	2636	197.85	137.75	0	840
Domestic work time	2636	417.79	167.63	0	1140
Productive work time	2636	118.73	150.82	0	1050
Household size	2657	4.49	1.56	1	12
Wealth index	2657	0.16	0.1	0.01	0.86
No-migrant t=2018-19					
Underweight child	3375	0.14	0.35	0	1
Underweight mother	1015	0.27	0.44	0	1
Underweight father	1678	0.27	0.45	0	1
School attendance	4528	0.78	0.42	0	1
Primary school attendance	1321	1	0.05	0	1
Secondary school attendance	2053	0.84	0.36	0	1
Personal time	2628	713.76	118.96	270	1335
Leisure time	2628	226.29	138.71	0	870
Domestic work time	2628	406.23	175.43	0	1200
Productive work time	2628	134.88	149.89	0	960
Household size	2657	5.03	1.79	1	15
Wealth index	2657	0.19	0.1	0	0.86

Table A3.5: Descriptive Statistics of Minutes Spent by Women in Daily Activities, Sample: Migrant Son (t=2015 and t=2018-19)

	N	Mean	SD	Min	Max
Migrant Son (t=2015)					
Sleeping and resting	472	555.29	123.47	225	1125
Eating and drinking	472	83.71	35.72	15	240
Personal care	472	73.76	37.63	0	495
Work as employed	472	15.22	83.17	0	750
Own business work	472	6.83	43.5	0	585
Farming	472	60.25	90.38	0	615
Shopping/getting service	472	2.38	23.45	0	435
Waeving, sewing, textile care	472	13.76	50.48	0	405
Cooking	472	139.29	74.68	0	375
Domestic work	472	234.5	139.82	0	900
Care for children/adults/elderly	472	51.55	78.45	0	675
Travelling	472	12.58	43.54	0	420
Watching TV/listening to radio	472	28.22	58.69	0	345
Exercising	472	1.88	10.65	0	105
Social activities	472	113.8	105.19	0	600
Religious activities	472	64	66.84	0	300
Migrant Son (t=2018-19)					
Sleeping and resting	471	560.76	128.68	210	1155
Eating and drinking	471	72.99	23.31	30	165
Personal care	471	87.42	31.27	15	195
Work as employed	471	12.87	71.39	0	675
Own business work	471	3.85	28.39	0	330
Farming	471	68.09	92.56	0	510
Shopping/getting service	471	3.22	20.82	0	240
Waeving, sewing, textile care	471	15.45	61.98	0	465
Cooking	471	122.9	74.7	0	375
Domestic work	471	184.11	100.69	0	570
Care for children/adults/elderly	470	57.99	95.93	0	585
Travelling	470	16.95	44.36	0	420
Watching TV/listening to radio	470	31.37	62.61	0	465
Exercising	470	2.55	16.01	0	240
Social activities	470	149.39	116.66	0	720
Religious activities	470	81.64	79.11	0	465

Table A3.6: Descriptive Statistics of Minutes Spent by Women in Daily Activities, Sample: Migrant Daughter (t=2015 and t=2018-19)

	N	Mean	SD	Min	Max
Migrant Daughter (t=2015)					
Sleeping and resting	322	562.69	128.61	240	1140
Eating and drinking	322	90.05	42.76	15	300
Personal care	322	73.88	34.17	0	240
Work as employed	322	25.76	116.64	0	810
Own business work	322	15	78.73	0	720
Farming	322	62.52	105.25	0	630
Shopping/getting service	322	3.26	21.72	0	240
Waeving, sewing, textile care	322	11.65	41.18	0	270
Cooking	322	140.73	80.09	0	315
Domestic work	322	210.09	140.74	0	795
Care for children/adults/elderly	322	48.82	74.76	0	510
Travelling	322	16.58	46.96	0	495
Watching TV/listening to radio	322	32.05	66.61	0	420
Exercising	322	1.68	10.72	0	105
Social activities	322	111.61	113.94	0	690
Religious activities	322	62.7	67.29	0	300
Migrant Daughter (t=2018-19)					
Sleeping and resting	318	562.12	129.47	240	1140
Eating and drinking	318	72.78	26.62	30	165
Personal care	318	88.68	31.06	30	195
Work as employed	318	9.62	71.24	0	735
Own business work	318	4.76	39.7	0	525
Farming	318	61.04	84.24	0	510
Shopping/getting service	318	4.01	24.88	0	285
Waeving, sewing, textile care	318	14.34	58.37	0	420
Cooking	318	128.58	76.09	0	375
Domestic work	318	193.63	107.11	0	555
Care for children/adults/elderly	318	54.29	92.22	0	495
Travelling	318	15.33	43.96	0	420
Watching TV/listening to radio	318	26.89	53.93	0	330
Exercising	318	4.34	18.71	0	135
Social activities	318	143.07	112.16	0	555
Religious activities	318	87.08	87.91	0	390

Table A3.7: Descriptive Statistics of Minutes Spent by Women in Daily Activities, Sample: Migrant Child (t=2015 and t=2018-19)

	N	Mean	SD	Min	Max
Migrant Child (t=2015)					
Sleeping and resting	638	558.01	123.77	225	1140
Eating and drinking	638	85.63	38.01	15	255
Personal care	638	73.89	36.65	0	495
Work as employed	638	19.68	99.17	0	810
Own business work	638	9.64	58.09	0	720
Farming	638	63.64	98.44	0	630
Shopping/getting service	638	2.54	22.68	0	435
Waeving, sewing, textile care	638	13.73	48.82	0	405
Cooking	638	140.57	75.2	0	375
Domestic work	638	227.96	141.32	0	900
Care for children/adults/elderly	638	49.8	74.27	0	675
Travelling	638	12.44	39.39	0	420
Watching TV/listening to radio	638	30.56	62.36	0	420
Exercising	638	1.9	11.22	0	105
Social activities	638	112.69	108.35	0	690
Religious activities	638	58.45	64.54	0	300
Migrant Child (t=2018-19)					
Sleeping and resting	634	563.12	125.96	210	1155
Eating and drinking	634	73.56	24.81	30	165
Personal care	634	87.21	31.64	15	195
Work as employed	634	12.26	72.07	0	720
Own business work	634	4.61	35.61	0	525
Farming	634	67.15	92.24	0	510
Shopping/getting service	634	3.67	22.96	0	285
Waeving, sewing, textile care	634	15.21	61.17	0	465
Cooking	634	126.22	74.71	0	375
Domestic work	634	187	102.21	0	570
Care for children/adults/elderly	633	57.39	94.2	0	585
Travelling	633	16.92	44.23	0	420
Watching TV/listening to radio	633	32.42	62.78	0	465
Exercising	633	3.18	17.43	0	240
Social activities	633	145.33	113.6	0	720
Religious activities	633	76.82	82.4	0	465

Table A3.8: Descriptive Statistics of Minutes Spent by Women in Daily Activities, Sample: No-Migrant (t=2015 and t=2018-19)

	N	Mean	SD	Min	Max
No-migrant t=2015					
Sleeping and resting	2636	562.61	127.47	90	1320
Eating and drinking	2636	86.12	42.19	0	645
Personal care	2636	73.26	32.38	0	405
Work as employed	2636	21.27	99.22	0	1005
Own business work	2636	8.78	56.73	0	1050
Farming	2636	58.51	87.39	0	720
Shopping/getting service	2636	2.7	18.69	0	405
Waeving, sewing, textile care	2636	15.5	55.63	0	480
Cooking	2636	141.85	74.18	0	600
Domestic work	2636	203.25	121.26	0	1005
Care for children/adults/elderly	2636	70	89.55	0	690
Travelling	2636	14.68	46.87	0	705
Watching TV/listening to radio	2636	32.72	64.34	0	420
Exercising	2636	2.33	16.66	0	405
Social activities	2636	113.18	108.78	0	720
Religious activities	2636	49.62	72.39	0	600
No-migrant t=2018-19					
Sleeping and resting	2628	556.17	116.21	195	1185
Eating and drinking	2628	73.14	24.4	0	210
Personal care	2628	84.44	32.22	15	270
Work as employed	2628	20.79	92.43	0	840
Own business work	2628	11.43	63.57	0	810
Farming	2628	71.66	96.12	0	765
Shopping/getting service	2628	2.45	15.4	0	240
Waeving, sewing, textile care	2628	12.77	52.44	0	600
Cooking	2628	133.02	70.79	0	465
Domestic work	2628	190.99	106.04	0	720
Care for children/adults/elderly	2628	79.76	112.34	0	720
Travelling	2628	18.22	44.49	0	810
Watching TV/listening to radio	2628	36.88	67.29	0	585
Exercising	2628	3.51	19.64	0	285
Social activities	2628	129.44	108.38	0	780
Religious activities	2628	56.46	72.05	0	465

Results

Table A3.9: First stage results

	(1)	(2)	(3)	(4)	(5)	(6)
IV Migrant Son	14.180***	12.734***				
	(0.230)	(0.246)				
IV Migrant Daughter			16.859***	16.143***		
			(0.265)	(0.297)		
IV Migrant child					14.479***	12.850***
					(0.217)	(0.227)
HH size		0.263***		0.285***		0.282***
		(0.010)		(0.013)		(0.009)
Child male		-0.403		0.000		-0.752**
		(0.227)		(.)		(0.255)
Wealth quintile 2		0.060		-0.066		0.053
		(0.082)		(0.104)		(0.070)
Wealth quintile 3		0.204*		0.268**		0.270***
		(0.080)		(0.099)		(0.067)
Wealth quintile 4		0.209**		0.135		0.231***
		(0.079)		(0.096)		(0.066)
Wealth quintile 5		-0.086		-0.555***		-0.220**
		(0.085)		(0.108)		(0.073)
Month 2		0.707***		0.935***		0.833***
		(0.091)		(0.141)		(0.084)
Month 3		1.150***		1.276***		1.178***
		(0.090)		(0.139)		(0.084)
Month 4		0.604***		0.298		0.456***
		(0.101)		(0.160)		(0.094)
Month 5		0.000		0.000		0.000
		(.)		(.)		(.)
Month 6		0.000		0.000		0.000
		(.)		(.)		(.)
Month 9		0.000		0.000		0.000
		(.)		(.)		(.)
Month 11		1.221***		1.531***		1.471***
		(0.114)		(0.167)		(0.102)
Month 12		0.155		1.071***		0.390***
		(0.115)		(0.157)		(0.100)
Constant	-4.631***	-6.718***	-4.761***	-7.218***	-3.464***	-5.756***
	(0.040)	(0.115)	(0.042)	(0.176)	(0.027)	(0.104)
N	4.6e+04	4.2e+04	4.6e+04	4.1e+04	4.6e+04	4.2e+04

Standard errors in parentheses * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table A3.10: Effect of migrant on left-behind's wellbeing - Outcome: Underweight Sibling

	(1) FE	(2) FE	(3) FE	(4) FE	(9) 2SLS	(10) 2SLS	(11) FE	(12) FE	(15) 2SLS	(16) 2SLS
Migrant Son	-0.115***	-0.062**			-0.448*	-0.413*				
	(0.020)	(0.021)			(0.212)	(0.187)				
Migrant daughter			-0.106***	-0.055*	-0.105	0.099				
			(0.024)	(0.025)	(0.239)	(0.197)				
Migrant child							-0.109***	-0.060***	-0.357***	-0.209***
							(0.017)	(0.018)	(0.051)	(0.054)
HH size		-0.037***		-0.039***		-0.022*		-0.036***		-0.025**
		(0.007)		(0.007)		(0.009)		(0.007)		(0.009)
Child male		0.001		-0.003		0.000		-0.001		0.029
		(0.121)		(0.121)	(.)	(0.121)		(0.152)		
Wealth quintile 2		-0.009		-0.010		-0.002		-0.010		-0.004
		(0.017)		(0.017)	(0.020)	(0.017)		(0.019)		
Wealth quintile 3		-0.011		-0.012		-0.012		-0.011		-0.015
		(0.020)		(0.020)	(0.023)	(0.020)		(0.022)		
Wealth quintile 4		-0.026		-0.027		-0.028		-0.026		-0.029
		(0.022)		(0.022)	(0.025)	(0.022)		(0.024)		
Wealth quintile 5		-0.032		-0.031		-0.053		-0.032		-0.047
		(0.026)		(0.026)	(0.030)	(0.026)		(0.029)		
Month 2		-0.018		-0.018		-0.011		-0.017		-0.008
		(0.015)		(0.015)	(0.016)	(0.015)		(0.016)		
Month 3		-0.042**		-0.042**		-0.031		-0.041**		-0.031
		(0.016)		(0.015)	(0.017)	(0.016)		(0.016)		
Month 4		0.026		0.027		0.023		0.026		0.025
		(0.017)		(0.017)	(0.018)	(0.017)		(0.017)		
Month 5		0.060**		0.061***		0.000		0.059**		0.000
		(0.018)		(0.018)	(.)	(0.018)		(.)		
Month 6		0.085*		0.087*		0.000		0.084*		0.000
		(0.040)		(0.040)	(.)	(0.040)		(.)		
Month 9		0.038		0.047		0.000		0.036		0.000
		(0.104)		(0.105)	(.)	(0.103)		(.)		
Month 11		-0.013		-0.015		0.000		-0.012		-0.007
		(0.026)		(0.026)	(0.028)	(0.026)		(0.027)		
Month 12		0.015		0.016		0.008		0.016		0.012
		(0.017)		(0.017)	(0.018)	(0.017)		(0.018)		
Constant	0.185***	0.402***	0.183***	0.410***	0.200***	0.331***	0.186***	0.397***	0.201***	0.344***
	(0.001)	(0.038)	(0.001)	(0.038)	(0.003)	(0.049)	(0.001)	(0.038)	(0.003)	(0.046)
N	1.2e+04	1.2e+04	1.2e+04	1.2e+04	1.2e+04	1.1e+04	1.2e+04	1.2e+04	1.2e+04	1.1e+04

Standard errors in parentheses * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table A3.11: Effect of migrant on left-behind's wellbeing - Outcome: Underweight mother

	(1)	(2)	(3)	(4)	(9)	(10)	(11)	(12)	(15)	(16)
	FE	FE	FE	FE	2SLS	2SLS	FE	FE	2SLS	2SLS
Migrant Son	-0.238***	-0.166***			-0.879**	-1.046**				
	(0.040)	(0.041)			(0.322)	(0.355)				
Migrant daughter			-0.191***	-0.119**	-0.041	0.315				
			(0.042)	(0.043)	(0.333)	(0.376)				
Migrant child							-0.219***	-0.155***	-0.468***	-0.312**
							(0.031)	(0.032)	(0.093)	(0.110)
HH size		-0.047***		-0.050***		-0.022		-0.044***		-0.042**
		(0.013)		(0.013)		(0.018)		(0.013)		(0.016)
Child male		0.494**		0.503**		0.000		0.487**		0.473**
		(0.169)		(0.168)	(.)	(0.169)		(0.171)		
Wealth quintile 2		-0.001		-0.003		0.018		-0.001		0.008
		(0.023)		(0.023)	(0.027)	(0.022)		(0.025)		
Wealth quintile 3		-0.040		-0.043		-0.022		-0.039		-0.035
		(0.027)		(0.027)	(0.034)	(0.027)		(0.030)		
Wealth quintile 4		-0.020		-0.023		-0.013		-0.019		-0.021
		(0.034)		(0.034)	(0.043)	(0.034)		(0.038)		
Wealth quintile 5		-0.012		-0.016		0.018		-0.011		-0.001
		(0.043)		(0.044)	(0.057)	(0.044)		(0.051)		
Month 2		-0.085***		-0.088***		-0.062*		-0.084***		-0.076**
		(0.022)		(0.022)	(0.026)	(0.022)		(0.024)		
Month 3		-0.173***		-0.177***		-0.142***		-0.169***		-0.160***
		(0.024)		(0.024)	(0.029)	(0.024)		(0.026)		
Month 4		-0.097***		-0.099***		-0.091***		-0.097***		-0.097***
		(0.023)		(0.023)	(0.027)	(0.023)		(0.024)		
Month 5		-0.094***		-0.095***		0.000		-0.097***		0.000
		(0.024)		(0.025)	(.)	(0.025)		(.)		
Month 6		-0.053		-0.052		0.000		-0.057		0.000
		(0.054)		(0.054)	(.)	(0.054)		(.)		
Month 9		0.023		0.018		0.000		0.007		0.000
		(0.120)		(0.124)	(.)	(0.125)		(.)		
Month 11		0.051		0.042		0.116*		0.053		0.066
		(0.044)		(0.043)	(0.055)	(0.043)		(0.048)		
Month 12		0.031		0.029		0.034		0.032		0.027
		(0.025)		(0.026)	(0.029)	(0.025)		(0.027)		
Constant	0.344***	0.621***	0.342***	0.638***	0.364***	0.506***	0.347***	0.611***	0.359***	0.599***
	(0.001)	(0.057)	(0.001)	(0.057)	(0.005)	(0.078)	(0.001)	(0.057)	(0.004)	(0.070)
N	4973.000	4973.000	4973.000	4973.000	4973.000	4441.000	4973.000	4973.000	4973.000	4452.000

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.12: Effect of migrant on left-behind's wellbeing - Outcome: Underweight father

	(1) FE	(2) FE	(3) FE	(4) FE	(9) 2SLS	(10) 2SLS	(11) FE	(12) FE	(15) 2SLS	(16) 2SLS
Migrant Son	-0.047	-0.017			-0.346*	-0.135				
	(0.026)	(0.027)			(0.155)	(0.132)				
Migrant daughter			-0.043	-0.015	0.038	-0.042				
			(0.029)	(0.031)	(0.179)	(0.160)				
Migrant child							-0.039	-0.010	-0.174**	-0.114
							(0.021)	(0.022)	(0.064)	(0.074)
HH size		-0.019**		-0.020**		-0.015		-0.019**		-0.015
		(0.007)		(0.007)		(0.009)		(0.007)		(0.009)
Child male		0.051		0.050		0.000		0.051		0.088
		(0.091)		(0.090)	(.)	(0.090)		(0.137)		
Wealth quintile 2		0.007		0.007		0.017		0.007		0.019
		(0.019)		(0.019)	(0.021)	(0.019)		(0.021)		
Wealth quintile 3		-0.014		-0.014		-0.012		-0.014		-0.011
		(0.022)		(0.022)	(0.023)	(0.022)		(0.023)		
Wealth quintile 4		-0.022		-0.023		-0.014		-0.023		-0.015
		(0.025)		(0.025)	(0.027)	(0.025)		(0.027)		
Wealth quintile 5		-0.023		-0.023		-0.014		-0.023		-0.016
		(0.032)		(0.032)	(0.034)	(0.032)		(0.034)		
Month 2		-0.008		-0.008		-0.001		-0.008		-0.000
		(0.018)		(0.018)	(0.019)	(0.018)		(0.019)		
Month 3		-0.033		-0.034		-0.028		-0.033		-0.028
		(0.019)		(0.019)	(0.020)	(0.019)		(0.020)		
Month 4		-0.013		-0.013		-0.015		-0.013		-0.014
		(0.021)		(0.021)	(0.021)	(0.021)		(0.021)		
Month 5		0.034		0.034		0.000		0.034		0.000
		(0.021)		(0.021)	(.)	(0.021)		(.)		
Month 6		0.052		0.053		0.000		0.052		0.000
		(0.040)		(0.040)	(.)	(0.040)		(.)		
Month 9		-0.067		-0.066		0.000		-0.067		0.000
		(0.110)		(0.109)	(.)	(0.110)		(.)		
Month 11		0.004		0.004		0.023		0.004		0.021
		(0.030)		(0.030)	(0.031)	(0.030)		(0.032)		
Month 12		0.003		0.003		0.005		0.003		0.006
		(0.020)		(0.020)	(0.021)	(0.020)		(0.021)		
_cons	0.324***	0.429***	0.323***	0.431***	0.335***	0.405***	0.324***	0.430***	0.332***	0.404***
	(0.001)	(0.036)	(0.001)	(0.036)	(0.004)	(0.041)	(0.001)	(0.036)	(0.003)	(0.042)
N	6563.000	6563.000	6563.000	6563.000	6563.000	5913.000	6563.000	6563.000	6563.000	5929.000

Standard errors in parentheses * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table A3.13: Effect of migrant on left-behind's wellbeing - Outcome: Secondary school attendance

	(1) FE	(2) FE	(3) FE	(4) FE	(9) 2SLS	(10) 2SLS	(11) FE	(12) FE	(15) 2SLS	(16) 2SLS
Migrant Son	-0.127***	-0.078**			-0.497**	-0.491**				
	(0.026)	(0.027)			(0.172)	(0.152)				
Migrant daughter			-0.114***	-0.079*	-0.023	0.170				
			(0.032)	(0.035)	(0.199)	(0.175)				
Migrant child							-0.129***	-0.088***	-0.336***	-0.203**
							(0.022)	(0.024)	(0.062)	(0.066)
HH size		-0.084***		-0.086***		-0.069***		-0.082***		-0.074***
		(0.011)		(0.011)		(0.014)		(0.011)		(0.014)
Child male		-0.058		-0.054		0.000		-0.063		-0.352*
		(0.144)		(0.144)	(.)	(0.144)		(0.169)		
Wealth quintile 2		-0.043		-0.042		-0.013		-0.043		-0.012
		(0.031)		(0.032)	(0.036)	(0.031)		(0.035)		
Wealth quintile 3		-0.086*		-0.085*		-0.034		-0.085*		-0.032
		(0.034)		(0.034)	(0.040)	(0.034)		(0.038)		
Wealth quintile 4		-0.127***		-0.127***		-0.071		-0.127***		-0.072
		(0.036)		(0.036)	(0.042)	(0.036)		(0.040)		
Wealth quintile 5		-0.133***		-0.133***		-0.061		-0.132***		-0.068
		(0.040)		(0.040)	(0.046)	(0.040)		(0.044)		
Month 2		-0.050*		-0.051*		-0.050*		-0.050*		-0.053*
		(0.020)		(0.020)	(0.023)	(0.020)		(0.022)		
Month 3		-0.090***		-0.090***		-0.070**		-0.090***		-0.068**
		(0.020)		(0.020)	(0.022)	(0.020)		(0.022)		
Month 4		-0.075***		-0.074***		-0.078**		-0.077***		-0.074**
		(0.022)		(0.022)	(0.025)	(0.022)		(0.024)		
Month 5		-0.041		-0.040		0.000		-0.044		0.000
		(0.023)		(0.023)	(.)	(0.023)		(.)		
Month 6		0.000		0.001		0.000		-0.005		0.000
		(0.048)		(0.049)	(.)	(0.049)		(.)		
Month 9		0.135		0.152		0.000		0.132		0.000
		(0.163)		(0.157)	(.)	(0.163)		(.)		
Month 11		-0.125**		-0.128***		-0.094*		-0.121**		-0.105*
		(0.039)		(0.039)	(0.042)	(0.039)		(0.041)		
Month 12		-0.007		-0.006		-0.010		-0.006		-0.003
		(0.023)		(0.023)	(0.026)	(0.023)		(0.025)		
_cons	0.859***	1.453***	0.857***	1.461***	0.879***	1.342***	0.863***	1.447***	0.878***	1.365***
	(0.001)	(0.066)	(0.001)	(0.066)	(0.005)	(0.076)	(0.002)	(0.066)	(0.004)	(0.076)
N	6751.000	6751.000	6751.000	6751.000	6751.000	6050.000	6751.000	6751.000	6751.000	6067.000

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.14: Effect of migrant on left-behind's wellbeing - Outcome: Time use for Productive work

	(1)	(2)	(3)	(4)	(9)	(10)	(11)	(12)	(15)	(16)
	FE	FE	FE	FE	2SLS	2SLS	FE	FE	2SLS	2SLS
Migrant Son	39.372***	20.672**			88.558	95.903*				
	(6.924)	(7.292)			(51.978)	(44.279)				
Migrant daughter			12.306	-8.018	43.747	-22.496				
			(8.479)	(8.978)	(58.152)	(44.788)				
Migrant child							30.615***	12.295	75.441***	42.368*
							(5.838)	(6.308)	(16.171)	(17.911)
HH size		10.033***		11.376***		7.506**		10.267***		8.656***
		(2.126)		(2.110)		(2.711)		(2.145)		(2.519)
Child male		-12.090		-13.174		0.000		-11.744		38.199
		(54.911)		(54.731)	(.)	(54.868)		(51.277)		
Wealth quintile 2		6.006		5.811		6.389		5.882		5.573
		(6.650)		(6.657)	(7.021)	(6.656)		(6.976)		
Wealth quintile 3		18.960*		19.010*		22.277**		18.924*		21.710**
		(7.784)		(7.787)	(8.054)	(7.787)		(8.004)		
Wealth quintile 4		24.845**		24.736**		31.152***		24.739**		30.711***
		(8.760)		(8.768)	(9.038)	(8.764)		(8.958)		
Wealth quintile 5		25.447*		24.596*		29.476**		25.206*		27.427*
		(10.431)		(10.456)	(10.978)	(10.452)		(10.857)		
Month 2		26.934***		27.487***		23.133***		26.964***		22.869***
		(4.933)		(4.936)	(5.129)	(4.938)		(5.111)		
Month 3		62.944***		64.254***		58.612***		63.060***		59.474***
		(5.238)		(5.220)	(5.620)	(5.244)		(5.566)		
Month 4		56.382***		56.373***		55.087***		56.314***		54.539***
		(5.751)		(5.751)	(5.827)	(5.755)		(5.824)		
Month 5		63.790***		63.001***		0.000		63.710***		0.000
		(6.872)		(6.871)	(.)	(6.877)		(.)		
Month 6		22.024*		20.028		0.000		21.803		0.000
		(11.116)		(11.090)	(.)	(11.143)		(.)		
Month 9		159.314*		156.122		0.000		159.026*		0.000
		(80.018)		(79.963)	(.)	(80.013)		(.)		
Month 11		23.437*		25.353**		15.364		23.783*		18.068
		(9.570)		(9.594)	(10.380)	(9.571)		(10.130)		
Month 12		-9.853		-9.438		-13.093*		-9.807		-13.617*
		(6.226)		(6.226)	(6.461)	(6.222)		(6.428)		
_cons	98.468***	4.836	99.931***	-0.477	95.010***	14.507	98.296***	3.967	95.404***	10.948
	(0.317)	(11.155)	(0.234)	(11.067)	(1.201)	(13.113)	(0.377)	(11.209)	(1.043)	(12.580)
N	9829.000	9829.000	9829.000	9829.000	9829.000	8888.000	9829.000	9829.000	9829.000	8907.000

Standard errors in parentheses * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table A3.15: Effect of migrant on left-behind's wellbeing - Outcome: Time use for Domestic work

	(1)	(2)	(3)	(4)	(9)	(10)	(11)	(12)	(15)	(16)
	FE	FE	FE	FE	2SLS	2SLS	FE	FE	2SLS	2SLS
Migrant Son	-87.065***	-73.964***			-150.535*	-192.284**				
	(8.692)	(8.989)			(64.513)	(59.139)				
Migrant daughter			-42.553***	-25.371*	-59.257	22.297				
			(11.537)	(12.058)	(74.020)	(63.028)				
Migrant child							-74.555***	-62.013***	-119.134***	-100.675***
							(7.408)	(7.783)	(20.382)	(23.829)
HH size		4.340		1.204		8.752*		4.766		5.916
		(3.007)		(2.989)		(3.680)		(3.038)		(3.445)
Child male		-116.223		-116.413		0.000		-118.673		-152.307*
		(65.693)		(66.294)	(.)	(66.066)		(68.041)		
Wealth quintile 2		1.931		2.576		1.087		2.283		2.337
		(7.284)		(7.308)	(8.043)	(7.273)		(7.843)		
Wealth quintile 3		-9.152		-9.141		-11.606		-8.941		-10.964
		(8.790)		(8.810)	(9.512)	(8.783)		(9.346)		
Wealth quintile 4		-11.211		-10.696		-17.961		-10.863		-16.657
		(10.076)		(10.105)	(10.717)	(10.063)		(10.515)		
Wealth quintile 5		-23.170		-20.945		-29.968*		-23.028		-26.304*
		(12.489)		(12.563)	(13.400)	(12.490)		(13.122)		
Month 2		-45.789***		-46.839***		-45.719***		-45.331***		-44.823***
		(6.116)		(6.137)	(6.351)	(6.119)		(6.311)		
Month 3		-74.137***		-76.956***		-69.830***		-73.207***		-71.028***
		(6.425)		(6.430)	(6.867)	(6.433)		(6.808)		
Month 4		-67.633***		-67.489***		-71.764***		-67.332***		-70.602***
		(7.141)		(7.165)	(7.354)	(7.148)		(7.291)		
Month 5		-33.350***		-31.529***		0.000		-33.888***		0.000
		(8.133)		(8.177)	(.)	(8.147)		(.)		
Month 6		-62.239***		-57.733***		0.000		-63.479***		0.000
		(16.804)		(16.885)	(.)	(16.882)		(.)		
Month 9		-1.119		6.903		0.000		-3.610		0.000
		(68.159)		(67.010)	(.)	(68.375)		(.)		
Month 11		-33.794**		-38.567***		-31.648*		-33.183**		-34.451**
		(11.706)		(11.655)	(12.676)	(11.643)		(12.109)		
Month 12		0.111		-0.719		-2.531		0.345		-2.033
		(7.539)		(7.556)	(7.854)	(7.527)		(7.796)		
_cons	436.933***	465.451***	434.121***	477.616***	441.473***	453.324***	437.756***	463.534***	440.632***	463.294***
	(0.398)	(14.573)	(0.318)	(14.488)	(1.477)	(16.853)	(0.478)	(14.666)	(1.315)	(16.094)
N	9829.000	9829.000	9829.000	9829.000	9829.000	8888.000	9829.000	9829.000	9829.000	8907.000

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.16: Effect of migrant on left-behind's wellbeing - Outcome: Time use for Leisure

	(1)	(2)	(3)	(4)	(9)	(10)	(11)	(12)	(15)	(16)
	FE	FE	FE	FE	2SLS	2SLS	FE	FE	2SLS	2SLS
Migrant Son	81.697***	61.882***			265.555***	313.130***				
	(7.625)	(8.044)			(61.500)	(58.812)				
Migrant daughter			63.553***	41.152***	-40.103	-153.991**				
			(9.312)	(9.879)	(67.772)	(58.573)				
Migrant child							75.721***	57.395***	122.913***	68.428***
							(6.345)	(6.803)	(17.057)	(18.163)
HH size		11.889***		13.899***		3.282		11.147***		10.457***
		(2.180)		(2.167)		(3.060)		(2.196)		(2.542)
Child male		28.705		30.363		0.000		31.125		17.802
		(41.862)		(41.339)	(.)	(41.719)		(42.150)		
Wealth quintile 2		1.371		0.850		3.728		1.104		0.716
		(5.898)		(5.927)	(7.063)	(5.897)		(6.411)		
Wealth quintile 3		5.121		5.040		6.625		4.919		5.572
		(6.921)		(6.934)	(8.208)	(6.915)		(7.367)		
Wealth quintile 4		1.659		1.182		4.138		1.377		1.574
		(8.004)		(8.032)	(9.499)	(7.988)		(8.481)		
Wealth quintile 5		11.128		9.568		18.708		11.228		11.949
		(9.831)		(9.874)	(11.815)	(9.787)		(10.405)		
Month 2		29.438***		29.975***		31.662***		28.883***		32.655***
		(4.829)		(4.872)	(5.483)	(4.834)		(5.080)		
Month 3		48.268***		49.939***		46.381***		47.079***		52.093***
		(5.275)		(5.322)	(6.123)	(5.298)		(5.646)		
Month 4		42.516***		42.353***		48.853***		42.245***		47.592***
		(5.582)		(5.621)	(6.118)	(5.583)		(5.714)		
Month 5		17.219**		16.065**		0.000		17.920**		0.000
		(6.153)		(6.178)	(.)	(6.148)		(.)		
Month 6		28.157*		25.359		0.000		29.816*		0.000
		(14.026)		(14.061)	(.)	(14.033)		(.)		
Month 9		-31.548		-37.007		0.000		-28.388		0.000
		(30.454)		(30.115)	(.)	(31.444)		(.)		
Month 11		2.685		5.910		-7.384		1.609		4.880
		(9.297)		(9.304)	(10.870)	(9.258)		(9.663)		
Month 12		7.167		7.621		10.163		6.849		11.438
		(5.926)		(5.962)	(6.693)	(5.920)		(6.215)		
_cons	191.528***	107.316***	193.516***	99.661***	184.216***	135.452***	190.384***	110.456***	187.340***	108.885***
	(0.349)	(10.746)	(0.257)	(10.686)	(1.458)	(14.239)	(0.409)	(10.809)	(1.100)	(12.186)
N	9829.000	9829.000	9829.000	9829.000	9829.000	8888.000	9829.000	9829.000	9829.000	8907.000

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.17: Effect of migrant on left-behind's wellbeing - Outcome: Time use for Personal time

	(1) FE	(2) FE	(3) FE	(4) FE	(9) 2SLS	(10) 2SLS	(11) FE	(12) FE	(15) 2SLS	(16) 2SLS
Migrant Son	-14.704*	-4.174			-61.520	-109.315*				
	(7.022)	(7.362)			(51.249)	(46.135)				
Migrant daughter			-21.320*	-10.695	-43.698	31.390				
			(8.828)	(9.037)	(55.914)	(46.267)				
Migrant child							-15.326**	-5.299	-55.718***	-32.288
							(5.781)	(6.149)	(15.578)	(17.234)
HH size		-8.220***		-8.111***		-3.389		-8.070***		-5.583*
		(2.146)		(2.130)		(2.603)		(2.169)		(2.471)
Child male		77.329*		76.622*		0.000		77.070*		75.684*
		(34.976)		(34.761)	(.)	(34.972)		(35.836)		
Wealth quintile 2		-13.803*		-13.776*		-14.236*		-13.793*		-12.912*
		(5.792)		(5.794)	(6.219)	(5.792)		(6.159)		
Wealth quintile 3		-22.692***		-22.658***		-25.673***		-22.671***		-25.027***
		(6.857)		(6.859)	(7.227)	(6.855)		(7.167)		
Wealth quintile 4		-25.238**		-25.188**		-27.591**		-25.222**		-26.908**
		(8.129)		(8.128)	(8.608)	(8.127)		(8.485)		
Wealth quintile 5		-27.273**		-27.287**		-31.067**		-27.336**		-29.000**
		(9.259)		(9.259)	(10.020)	(9.258)		(9.792)		
Month 2		-7.165		-7.065		-7.588		-7.083		-8.277
		(4.593)		(4.588)	(4.836)	(4.592)		(4.787)		
Month 3		-35.560***		-35.399***		-34.952***		-35.373***		-37.093***
		(5.173)		(5.143)	(5.601)	(5.167)		(5.458)		
Month 4		-29.063***		-29.036***		-30.951***		-29.040***		-30.637***
		(5.563)		(5.565)	(5.764)	(5.563)		(5.716)		
Month 5		-52.301***		-52.370***		0.000		-52.413***		0.000
		(5.988)		(5.992)	(.)	(5.992)		(.)		
Month 6		7.099		6.902		0.000		6.827		0.000
		(15.506)		(15.507)	(.)	(15.523)		(.)		
Month 9		-23.851		-23.980		0.000		-24.343		0.000
		(28.627)		(28.792)	(.)	(28.670)		(.)		
Month 11		5.663		5.751		12.666		5.882		7.769
		(8.727)		(8.703)	(9.465)	(8.733)		(9.129)		
Month 12		6.544		6.610		6.261		6.597		5.864
		(5.679)		(5.677)	(5.952)	(5.679)		(5.898)		
_cons	733.144***	804.740***	733.059***	804.254***	736.493***	788.056***	733.460***	804.130***	736.065***	795.865***
	(0.321)	(10.946)	(0.243)	(10.881)	(1.214)	(12.318)	(0.373)	(11.005)	(1.005)	(12.024)
N	9829.000	9829.000	9829.000	9829.000	9829.000	8888.000	9829.000	9829.000	9829.000	8907.000

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.18: First stage results (1SLS) by gender of the sibling left-behind

	(1) Brother	(2) Brother	(3) Sister	(4) Sister	(5) Brother	(6) Brother	(7) Sister	(8) Sister	(9) Brother	(10) Sister	(11) Brother	(12) Sister
IV Migrant Son	14.567***		13.912***		13.074***		12.533***					
	(43.19)		(43.94)		(36.48)		(36.60)					
IV Migrant Daughter		16.681***		17.043***		16.003***		16.355***				
		(41.02)		(48.52)		(34.10)		(41.99)				
IV Migrant child									14.028***	14.880***	12.290***	13.373***
									(44.52)	(49.51)	(37.58)	(42.35)
HH size					0.244***	0.312***	0.284***	0.267***			0.274***	0.290***
					(16.49)	(15.64)	(19.01)	(15.71)			(19.98)	(22.07)
Child male					-0.307	0.000	-0.519	0.000			-0.570	-0.964*
					(-0.95)	(.)	(-1.65)	(.)			(-1.67)	(-2.57)
Wealth quintile 2					0.013	0.120	0.111	-0.179			0.091	0.018
					(0.11)	(0.72)	(0.93)	(-1.32)			(0.91)	(0.18)
Wealth quintile 3					0.170	0.329*	0.240*	0.247			0.283**	0.260**
					(1.53)	(2.06)	(2.05)	(1.94)			(2.89)	(2.78)
Wealth quintile 4					0.196	0.305*	0.220	0.035			0.296**	0.170
					(1.81)	(1.99)	(1.90)	(0.28)			(3.10)	(1.83)
Wealth quintile 5					-0.064	-0.389*	-0.112	-0.653***			-0.141	-0.297**
					(-0.55)	(-2.26)	(-0.90)	(-4.62)			(-1.35)	(-2.90)
Month 2					0.785***	0.911***	0.627***	0.962***			0.884***	0.786***
					(6.08)	(4.02)	(4.83)	(5.30)			(7.26)	(6.82)
Month 3					1.208***	1.278***	1.094***	1.286***			1.215***	1.146***
					(9.51)	(5.74)	(8.60)	(7.21)			(9.98)	(9.98)
Month 4					0.712***	0.110	0.496***	0.425*			0.489***	0.428***
					(5.01)	(0.42)	(3.41)	(2.10)			(3.56)	(3.30)
Month 5					0.000	0.000	0.000	0.000			0.000	0.000
					(.)	(.)	(.)	(.)			(.)	(.)
Month 6					0.000	0.000	0.000	0.000			0.000	0.000
					(.)	(.)	(.)	(.)			(.)	(.)
Month 9					0.000	0.000	0.000	0.000			0.000	0.000
					(.)	(.)	(.)	(.)			(.)	(.)
Month 11					1.186***	1.443***	1.242***	1.614***			1.420***	1.515***
					(7.35)	(5.43)	(7.70)	(7.47)			(9.52)	(10.78)
Month 12					0.151	1.032***	0.158	1.114***			0.329*	0.447**
					(0.93)	(4.09)	(0.97)	(5.52)			(2.25)	(3.29)
_cons	-4.563***	-4.955***	-4.712***	-4.616***	-6.558***	-7.681***	-6.904***	-6.929***	-3.411***	-3.514***	-5.705***	-5.811***
	(-81.33)	(-74.88)	(-83.54)	(-86.08)	(-40.44)	(-27.95)	(-41.74)	(-30.30)	(-89.49)	(-94.77)	(-38.18)	(-39.89)
N	2.2e+04	2.2e+04	2.4e+04	2.4e+04	2.0e+04	2.0e+04	2.2e+04	2.2e+04	2.2e+04	2.4e+04	2.0e+04	2.2e+04

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.19: Effect of migrant (by gender) on left-behind's wellbeing heterogeneity by gender of the sibling left-behind - Outcome: Underweight child

	(1) Brother	(2) Sister	(3) Brother	(4) Sister	(5) Brother	(6) Sister	(7) Brother	(8) Sister
Migrant Son	-0.709*	-0.154	-0.500*	-0.348				
	(-2.46)	(-0.47)	(-2.31)	(-1.11)				
Migrant Daughter	0.064	-0.400	0.088	0.084				
	(0.22)	(-0.99)	(0.41)	(0.23)				
Migrant Child					-0.352***	-0.362***	-0.191*	-0.223**
					(-4.45)	(-5.51)	(-2.25)	(-3.28)
HH size			-0.027*	-0.017			-0.035**	-0.018
			(-1.97)	(-1.49)			(-2.58)	(-1.69)
Child male			0.000	0.000			0.345	-0.171
			(.)	(.)			(1.41)	(-1.08)
Wealth quintile 2			-0.000	-0.001			-0.011	0.002
			(-0.01)	(-0.02)			(-0.40)	(0.09)
Wealth quintile 3			-0.004	-0.017			-0.016	-0.014
			(-0.11)	(-0.54)			(-0.51)	(-0.46)
Wealth quintile 4			-0.030	-0.023			-0.037	-0.021
			(-0.86)	(-0.66)			(-1.10)	(-0.60)
Wealth quintile 5			-0.044	-0.059			-0.040	-0.056
			(-1.08)	(-1.32)			(-1.02)	(-1.28)
Month 2			-0.015	-0.008			-0.013	-0.003
			(-0.67)	(-0.34)			(-0.60)	(-0.12)
Month 3			-0.034	-0.029			-0.035	-0.026
			(-1.44)	(-1.26)			(-1.51)	(-1.14)
Month 4			0.034	0.011			0.037	0.012
			(1.32)	(0.43)			(1.52)	(0.50)
Month 5			0.000	0.000			0.000	0.000
			(.)	(.)			(.)	(.)
Month 6			0.000	0.000			0.000	0.000
			(.)	(.)			(.)	(.)
Month 9			0.000	0.000			0.000	0.000
			(.)	(.)			(.)	(.)
Month 11			-0.010	0.011			-0.024	0.015
			(-0.26)	(0.27)			(-0.67)	(0.36)
Month 12			0.005	0.010			0.006	0.017
			(0.19)	(0.39)			(0.25)	(0.67)
_cons	0.225***	0.178***	0.376***	0.283***	0.220***	0.182***	0.412***	0.286***
	(44.33)	(45.93)	(4.99)	(4.56)	(51.93)	(45.02)	(5.78)	(4.84)
N	5946	6056	5333	5420	5946	6056	5346	5439

Standard errors in parentheses * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table A3.20: Effect of migrant (by gender) on left-behind's wellbeing heterogeneity by gender of sibling left-behind - Outcome: Secondary school attendance

	(1) Brother	(2) Sister	(3) Brother	(4) Sister	(5) Brother	(6) Sister	(7) Brother	(8) Sister
Migrant Son	-0.860***	-0.204	-0.750***	-0.168				
	(-3.34)	(-0.95)	(-3.30)	(-0.88)				
Migrant Daughter	0.044	-0.033	0.200	-0.040				
	(0.16)	(-0.13)	(0.83)	(-0.18)				
Migrant Child					-0.352***	-0.362***	-0.191*	-0.223**
					(-4.45)	(-5.51)	(-2.25)	(-3.28)
HH size			-0.082***	-0.049**			-0.035**	-0.018
			(-3.59)	(-3.14)			(-2.58)	(-1.69)
Child male			0.000	0.000			0.345	-0.171
			(.)	(.)			(1.41)	(-1.08)
Wealth quintile 2			-0.036	0.022			-0.011	0.002
			(-0.65)	(0.52)			(-0.40)	(0.09)
Wealth quintile 3			-0.056	0.009			-0.016	-0.014
			(-0.89)	(0.21)			(-0.51)	(-0.46)
Wealth quintile 4			-0.110	0.003			-0.037	-0.021
			(-1.63)	(0.08)			(-1.10)	(-0.60)
Wealth quintile 5			-0.091	0.025			-0.040	-0.056
			(-1.20)	(0.53)			(-1.02)	(-1.28)
Month 2			-0.038	-0.077**			-0.013	-0.003
			(-1.06)	(-2.91)			(-0.60)	(-0.12)
Month 3			-0.101**	-0.053*			-0.035	-0.026
			(-2.63)	(-2.24)			(-1.51)	(-1.14)
Month 4			-0.096*	-0.087**			0.037	0.012
			(-2.28)	(-3.07)			(1.52)	(0.50)
Month 5			0.000	0.000			0.000	0.000
			(.)	(.)			(.)	(.)
Month 6			0.000	0.000			0.000	0.000
			(.)	(.)			(.)	(.)
Month 9			0.000	0.000			0.000	0.000
			(.)	(.)			(.)	(.)
Month 11			-0.170*	-0.049			-0.024	0.015
			(-2.37)	(-1.22)			(-0.67)	(0.36)
Month 12			0.006	-0.053			0.006	0.017
			(0.13)	(-1.84)			(0.25)	(0.67)
_cons	0.864***	0.896***	1.418***	1.212***	0.220***	0.182***	0.412***	0.286***
	(88.85)	(224.88)	(11.91)	(13.69)	(51.93)	(45.02)	(5.78)	(4.84)
N	3388.000	3363.000	3046.000	3004.000	5946.000	6056.000	5346.000	5439.000

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.21: Effect of migrant on mother' time use for each activity of Domestic and Productive Work

	Domestic Work Time				Productive Work Time				
	Cooking	Domestic work	Care for others	Shopping, Services	Work as employed	Own business	Farming	Weaving, sewing, textile care	Commuting, Travelling
Migrant Sibling	-11.076	-18.32	-73.341***	1.807	6.935	2.758	20.304	17.501*	-7.914
	(10.592)	(16.319)	(13.319)	(2.912)	(9.794)	(6.278)	(10.873)	(8.609)	(5.636)
Migrant Son	38.39	-80.149*	-147.458***	-2.712	-34.996	-0.664	72.715*	30.606	27.914*
	(27.426)	(40.681)	(37.205)	(8.099)	(21.062)	(14.030)	(31.371)	(24.056)	(13.108)
Migrant Daughter	-47.901	42.184	22.942	4.56	33.943	1.136	-29.637	5.039	-34.991*
	(28.823)	(43.404)	(38.731)	(7.512)	(24.838)	(16.356)	(29.165)	(22.153)	(15.422)
Diff(Son-Dau)	*86.291*	*-122.333*	*-170.400***	*-7.273*	*-68.940*	*-1.800*	*102.353**	*25.566*	*62.906***
SE	*(53.445)*	*(79.888)*	*(72.867)*	*(14.924)*	*(43.550)*	*(29.182)*	*(57.697)*	*(43.900)*	*(27.339)*

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.22: Effect of migrant on mother' time use for each activity of Personal and Leisure time

	Personal Time			Leisure Time			
	Sleeping, resting	Eating, drinking	Personal care	Watching TV/ listening to radio	Exercising	Social activities	Religious activities
Migrant Sibling	-0.65	-57.79***	26.15***	-9.10	5.37*	66.59***	51.68***
	(16.55)	(5.64)	(5.23)	(7.60)	(2.33)	(14.70)	(9.28)
Migrant Son	-62.08	-62.50***	15.27	71.20**	0	272.42***	-44.65
	(43.85)	(14.49)	(12.76)	(23.24)	(6.37)	(47.70)	(24.96)
Migrant Daughter	47.47	-35.84*	19.77	-71.46**	7.84	-115.70*	105.39***
	(44.33)	(15.76)	(14.33)	(23.33)	(6.58)	(47.31)	(27.53)
Diff(Son-Dau)	*-109.55*	*-26.66*	*-4.50*	*142.66****	*-7.84*	*388.12****	*-150.04****
SE	*(84.09)*	*(28.92)*	*(26.07)*	*(44.68)*	*(12.44)*	*(89.88)*	*(50.24)*

Standard errors in parentheses * p < 0.05 ** p < 0.01 *** p < 0.001

Table A3.23: Effect of migrant on left-behind's wellbeing - Outcome: Underweight mother

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Migrant Son	-1.203**			-1.195**						
	(-3.58)			(-3.36)						
IV Migrant Son		0.892**	0.286*		0.847***	0.203				
		(7.44)	(2.59)		(5.97)	(1.53)				
Migrant Daughter	0.237			0.250						
	(0.71)			(0.74)						
IV Migrant Daughter		0.100	0.853**		0.081	0.872**				
		(0.75)	(5.31)		(0.58)	(5.47)				
Migrant Child							-0.454**		-0.330*	
							(-5.48)		(-2.58)	
IV Migrant Child								1.793**		1.434**
								(12.87)		(8.54)
Controls				yes	yes	yes			yes	yes
N	2230	2230	2230	2230	2230	2230	2230	2230	2230	2230

t-statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Table A3.24: Effect of migrant on left-behind's wellbeing - Outcome: Underweight father

	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(4)	(5)	(8)
Migrant Son	-0.539***			-0.319						
	(-3.38)			(-1.73)						
IV Migrant Son		1.004***	0.150		0.917***	0.159				
		(9.87)	(1.92)		(7.65)	(1.71)				
Migrant Daughter	0.179			0.264						
	(0.91)			(1.38)						
IV Migrant Daughter		0.136	0.827***		0.081	0.824***				
		(1.22)	(6.92)		(0.69)	(6.93)				
Migrant Child							-0.221***		0.028	
							(-3.82)		(0.31)	
IV Migrant Child								1.702***		1.312***
								(15.47)		(10.15)
Controls				yes	yes	yes			yes	yes
N	3556	3556	3556	3556	3556	3556	3556	3556	3556	3556

t-statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Table A3.25: Effect of migrant on left-behind's wellbeing - Outcome: Underweight Sibling

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Migrant Son	-0.914***			-0.485*						
	(-4.51)			(-2.32)						
IV Migrant Son		0.861***	0.163*		0.827***	0.185*				
		(10.27)	(2.29)		(8.37)	(2.21)				
Migrant Daughter	0.166			0.127						
	(0.71)			(0.63)						
IV Migrant Daughter		0.318***	0.914***		0.262**	0.941***				
		(3.48)	(9.34)		(2.77)	(9.49)				
Migrant Child							-0.453***		-0.171*	
							(-8.68)		(-2.39)	
IV Migrant Child								1.776***		1.480***
								(20.95)		(14.76)
Controls				yes	yes	yes			yes	yes
N	5176	5176	5176	5176	5176	5176	5176	5176	5176	5176

t-statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Table A3.26: Effect of migrant on left-behind's wellbeing - Outcome: Secondary school attendance

	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(4)	(5)	(8)
Migrant Son	-0.648***			-0.195						
	(-3.75)			(-1.29)						
IV Migrant Son		1.138***	0.184		1.173***	0.136				
		(8.17)	(1.77)		(6.97)	(1.09)				
Migrant Daughter	-0.140			-0.095						
	(-0.68)			(-0.57)						
IV Migrant Daughter		0.195	1.018***		0.161	1.028***				
		(1.30)	(6.75)		(1.06)	(6.71)				
Migrant Child							-0.478***		-0.175*	
							(-7.86)		(-2.54)	
IV Migrant Child								1.991***		1.659***
								(14.98)		(10.66)
Controls				yes	yes	yes			yes	yes
N	2298	2298	2298	2298	2298	2298	2298	2298	2298	2298

t-statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Table A3.27: Effect of migrant on left-behind's wellbeing - Outcome: Domestic work

	(1)	(2)	(3)	(4)		(6)	(1)	(4)	(5)	(8)
Migrant Son	-147.002*			-197.635**						
	(-2.48)			(-2.60)						
IV Migrant Son		0.945***	0.131*		0.843***	0.112				
		(11.68)	(2.15)		(8.84)	(1.52)				
Migrant Daughter	15.707			49.932						
	(0.22)			(0.68)						
IV Migrant Daughter		0.302**	0.968***		0.254**	0.974***				
		(3.19)	(10.57)		(2.63)	(10.63)				
Migrant Child							-78.290***		-67.135*	
							(-3.97)		(-2.34)	
IV Migrant Child								1.879***		1.510***
								(22.92)		(15.72)
Controls				yes	yes	yes			yes	yes
N	6176	6176	6176	6176	6176	6176	6176	6176	6176	6176

t-statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Table A3.28: Effect of migrant on left-behind's wellbeing - Outcome: Productive work

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Migrant Son	133.083**			80.513						
	(2.63)			(1.32)						
IV Migrant Son		0.945***	0.131*		0.843***	0.112				
		(11.68)	(2.15)		(8.84)	(1.52)				
Migrant Daughter	-98.146			-80.410						
	(-1.63)			(-1.39)						
IV Migrant Daughter		0.302**	0.968***		0.254**	0.974***				
		(3.19)	(10.57)		(2.63)	(10.63)				
Migrant Child							22.594		-14.171	
							(1.39)		(-0.59)	
IV Migrant Child								1.879***		1.510***
								(22.92)		(15.72)
Controls				yes	yes	yes			yes	yes
N	6176	6176	6176	6176	6176	6176	6176	6176	6176	6176

t-statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Table A3.29: Effect of migrant on left-behind's wellbeing - Outcome: Personal time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Migrant Son	-13.510			72.853						
	(-0.29)			(1.25)						
IV Migrant Son		0.945***	0.131*		0.843***	0.112				
		(11.68)	(2.15)		(8.84)	(1.52)				
Migrant Daughter	-19.015			-54.455						
	(-0.34)			(-0.98)						
IV Migrant Daughter		0.302**	0.968***		0.254**	0.974***				
		(3.19)	(10.57)		(2.63)	(10.63)				
Migrant Child							-18.965		-0.170	
							(-1.20)		(-0.01)	
IV Migrant Child								1.879***		1.510***
								(22.92)		(15.72)
Controls				yes	yes	yes			yes	yes
N	6176	6176	6176	6176	6176	6176	6176	6176	6176	6176

t-statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Table A3.30: Effect of migrant on left-behind's wellbeing - Outcome: Leisure time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Migrant Son	183.805***			40.508						
	(3.67)			(0.69)						
IV Migrant Son		0.945***	0.131*		0.843***	0.112				
		(11.68)	(2.15)		(8.84)	(1.52)				
Migrant Daughter	0.699			5.091						
	(0.01)			(0.09)						
IV Migrant Daughter		0.302**	0.968***		0.254**	0.974***				
		(3.19)	(10.57)		(2.63)	(10.63)				
Migrant Child							109.591***		24.354	
							(6.63)		(1.04)	
IV Migrant Child								1.879***		1.510***
								(22.92)		(15.72)
Controls				yes	yes	yes			yes	yes
N	6176	6176	6176	6176	6176	6176	6176	6176	6176	6176

t-statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Table A3.31: Effect of migrant on left-behind's wellbeing, heterogeneity by the gender – Migrant child - Outcome: Underweight sibling

	(1) Brother	(2) Brother	(3) Brother	(4) Brother	(5) Sister	(6) Sister	(7) Sister	(8) Sister
Migrant Child	-0.478***		-0.155		-0.432***		-0.184	
	(-5.88)		(-1.42)		(-6.39)		(-1.94)	
IV Migrant Child		1.598***		1.344***		1.965***		1.612***
		(13.95)		(9.68)		(15.67)		(11.04)
Controls			yes	yes			yes	yes
N	2696	2696	2696	2696	2480	2480	2480	2480

t-statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A3.32: Effect of migrant on left-behind's wellbeing, heterogeneity by the gender – Migrant son and daughter - Outcome: Underweight sibling

	(1) Brother	(2) Brother	(3) Brother	(4) Brother	(5) Brother	(6) Brother	(7) Sister	(8) Sister	(9) Sister	(10) Sister	(11) Sister	(12) Sister
Migrant Son	-1.181***			-0.848*			-0.624*			-0.138		
	(-4.04)			(-2.38)			(-2.18)			(-0.52)		
IV Migrant Son		0.759***	0.073		0.696***	0.162		0.974***	0.265*		0.974***	0.232
		(6.88)	(0.79)		(5.27)	(1.50)		(7.62)	(2.39)		(6.51)	(1.79)
Migrant Daughter	0.322			0.320			-0.057			-0.146		
	(0.97)			(1.08)			(-0.17)			(-0.50)		
IV Migrant Daughter		0.248*	0.878***		0.187	0.901***		0.386**	0.945***		0.319*	0.956***
		(2.07)	(6.63)		(1.52)	(6.69)		(2.76)	(6.48)		(2.21)	(6.53)
Controls				yes	yes	yes				yes	yes	yes
N	2696	2696	2696	2696	2696	2696	2480	2480	2480	2480	2480	2480

t-statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A3.33: Effect of migrant on left-behind's wellbeing, heterogeneity by the gender– Migrant child - Outcome: School attendance

	(1) Brother	(2) Brother	(3) Brother	(4) Brother	(5) Sister	(6) Sister	(7) Sister	(8) Sister
Migrant Child	-0.400***		-0.171***		-0.244***		-0.146***	
	(-9.71)		(-3.40)		(-7.82)		(-3.46)	
IV Migrant Child		1.965***		1.648***		1.937***		1.551***
		(20.70)		(14.50)		(19.54)		(13.44)
Controls			yes	yes			yes	yes
N	4428	4428	4428	4428	4024	4024	4024	4024

t-statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A3.34: Effect of migrant on left-behind's wellbeing, heterogeneity by the gender– Migrant son and daughter - Outcome: School attendance

	(1) Brother	(2) Brother	(3) Brother	(4) Brother	(5) Brother	(6) Brother	(7) Sister	(8) Sister	(9) Sister	(10) Sister	(11) Sister	(12) Sister
Migrant Son	-0.817***			-0.427**			-0.211*			-0.032		
	(-4.81)			(-2.66)			(-2.42)			(-0.34)		
IV Migrant Son		0.931***	0.161*		0.912***	0.148		1.066***	0.273**		0.987***	0.235*
		(9.45)	(2.06)		(7.82)	(1.57)		(10.44)	(3.29)		(8.21)	(2.41)
Migrant Daughter	0.199			0.118			-0.194			-0.177*		
	(0.87)			(0.63)			(-1.94)			(-1.97)		
IV Migrant Daughter		0.408***	0.895***		0.351**	0.885***		0.193	0.980***		0.139	0.994***
		(3.63)	(8.15)		(3.02)	(7.99)		(1.77)	(8.74)		(1.25)	(8.83)
Controls				yes	yes	yes				yes	yes	yes
N	4428	4428	4428	4428	4428	4428	4024	4024	4024	4024	4024	4024

t-statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$